Trial Frame for both Spherical
Independent P.D. Adj
Sides, Bridge Adjus
for Rotating Cylinders

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THE TREATMENT OF TRAUMATIC DIPLOPIA

BY

Group Captain J. C. NEELY
CONSULTANT IN OPHTHALMOLOGY, ROYAL AIR FORCE

Scope of the work

IN the Royal Air Force in 1937 an investigation was carried out concerning the incidence and the causes of accommodative asthenopia.

Before the war motor cycle accidents rather than aircraft crashes were responsible for the majority of head injuries, and they, in their turn, were often the cause of accommodative asthenopia. Usually some weakness of convergence was found to be associated with the condition, although, as the adverb implies, this association was by no means invariable. The investigation was therefore carried a stage further, and the other extra-ocular muscles were examined.

To make a finer estimate of the paresis of the particular muscle or muscles at fault, the Hess screen was used to record the initial weakness and the stages of any subsequent recovery. The Hess charts 1 and 2 are examples which show the extent of the diplopia when an airman was first examined following an aeroplane accident, and at a later date, when recovery was still taking place.

Owing to the author's service overseas, this investigation was not completed; it is mentioned, however, in order to support the contention that cases of traumatic diplopia, although uncommon in times of peace, are not by any means rare. From experience of this war, it seems that the condition is more common than is realised, not only by doctors, but also by ophthalmologists.

On returning to England in 1942, a fresh start was made to gather together the threads of this investigation and to watch the pattern emerge on the fuller canvas afforded by the material of war. At the beginning of the 1939-45 war, Lyle, who was then serving in the R.A.F., was working on the composition of this tangled tapestry, and by 1942 the form of the picture may be said to have taken definite shape. The material of this paper has been drawn from the records of patients, who were seen by the writer at a Military Hospital for Head Injuries, and at a R.A.F. Hospital. In each case, the description includes that of the injury which caused the diplopia, the ocular state of the patient before and after treatment, and the final disposal. The investigation of the case and the treatment, both surgical and orthoptic, now follow established principles. Under the more exacting conditions of war, the results have been tested and, because symptoms have been relieved and in the majority of cases the patient has returned to duty, these results are thought to show a definite advance in modern practice.

Previous history

Looking back through the history of ophthalmology for those oculists of the past who first thought of the various ways by which crooked eyes might be straightened and diplopia overcome, it seems that to Chevalier Taylor, that prince of ophthalmic charlatans, the credit must be given of being the first to think of curing squints by operations.[1] His operative technique is described by Lecat[2] and is of interest in showing how near Taylor was in theory to modern practice and also in his explanation of the trick which he used to straighten the squinting eye. Lecat, in writing of Taylor's visit to Rouen in 1743, tells how the door of his hotel was guarded by soldiers, and that an appointment had to be made in order to see him. He then describes his operations, and comes to " La grande operation, le plus merveilleuse de toutes "; this was the operation for the cure of squint. Taylor picked up a piece of conjunctiva at the inferior part of the globe, cut it off with scissors, applied a bandage to the sound eye, and the miraculous occurred; the squinting eye became straight. Taylor explained that the reason for the operation was to cut a nerve filament to the overacting muscle. Coats[3] considers that Taylor became

convinced that the operation was impracticable and that, in order not to lose the dishonest emoluments, he devised the fraudulent procedure described by Lecat. How Lecat exposed him at a dinner party by means of a dissected human head is of interest, but not germane to the subject; it is pertinent to note, however, that Taylor knew of a man who was greatly troubled with traumatic diplopia, that he clearly distinguished between ordinary squint and paralytic squint due to injury of the ocular muscles, and knew also of the development of suppression in the squinting eye. After Taylor's "Operation," "The proposal to divide a muscle for a squint slumbered for nearly a century till it was put into practice on the cadaver by Strohmeyer, and on the living in 1838 by Dieffenbach."

Dieffenbach was the first to carry out the surgical procedure of exposing the belly of the overacting muscle and cutting across its fibres: the operation had to be abandoned, however, because the muscle lost all its power.[4] Since that time innumerable operations for squint have been devised; they nearly all concern themselves with the problem of straightening a lateral deviation. Compared with these, there are very few references in the scientific press to the vertical deviations and their correction; those relating to traumatic diplopia and its treatment are even more scanty, and the librarian of the Royal Society of Medicine could provide only two[5 and 6]. In 1864 von Graefe was investigating the causes of ocular torticollis, and it was treated by operation by Knapp in 1874. The technique of operating on the inferior oblique of the same side in cases of paralysis of the superior oblique was developed by Landolt, while von Graefe and von Kries were more in favour of a tenotomy of the inferior rectus of the opposite side.[7] Stanculeanu[8] describes three cases of vertical diplopia: two following radical cure of the frontal sinus, and one due to an injury by a cow's horn. In all these subjects the operation performed was an advancement of the inferior rectus on the side of the injury. The merits and shortcomings of this operation will be discussed later. De Morsier at Barbey[9] in describing the predominance of unilateral provoked nystagmus in cases of post concussional giddiness included that of a farmer who suffered from a traumatic diplopia due to paralysis of the right superior oblique. No treatment, however, was included in the account which was of the nystagmus rather than the diplopia.

Present day practice

It may be seen from the paucity of historical material that the condition has been treated only by a very few ophthalmic surgeons in the past, and that no wide study of the possibilities of treatment or of the results of operation has been made until the recent war.

The attitude of the majority of British ophthalmologists appears to be but a continuation of this policy, and the impression is widespread that little can be done when dealing with a case of traumatic diplopia. Prisms are sometimes prescribed if the ocular deviation is not too marked, or occlusion of the affected eye may be advised until suppression of the false image makes life more endurable for the sufferer. Operative measures are hardly ever advocated.

It seems that the following extracts from two popular text-books of ophthalmology may be quoted as reflecting present day thought and teaching. "The diplopia may sometimes be relieved by suitable prisms, but this treatment is rarely of much use, owing to the variation in the amount of deviation in different positions of the eyes. Occasionally good is done by exercising the weak muscle with strong prisms. In old cases an operation may be indicated, usually a tenotomy of the antagonist with the advancement of the paralysed muscle, thus putting the affected muscle under better mechanical conditions. It is only suitable for paretic, not paralytic, cases and should *never* be adopted until all other means fail. It is, therefore, seldom indicated."[10] "Paralysis of the vertical recti, or an oblique muscle, is much more difficult to relieve, and the last has been, for the most part, regarded as irremediable by operation."[4] Treatment by prisms of the required strength divided between the two eyes has been the method of choice of most British ophthalmologists. This method is rarely satisfactory, and renders the wearer completely dependent on his glasses. In civilian life this is a great disadvantage, especially when the subject is playing games or driving a car, while in a flying service it effectively bars the wearer from many active appointments.

It may be seen that the somewhat ill marked sign-posts which were erected on the Continent towards the end of the last century became practically indecipherable, and were too few in number to be of use in directing ophthalmologists towards a proven way of treatment. Of this generation it seems that it was Chavasse[11] who again began to show the way. He established certain principles regarding the phenomenon of overaction of the synergic muscle, secondary deviation of the sound eye, and the tendency that the incomitance has to disappear with the passage of time. Before his death, he also succeeded in applying the principles of orthopaedic surgery—advocated by Haab in 1905—to the correction of defects of the ocular muscles.[12] It is these principles, enthusiastically taken up by Keith Lyle, coupled with the use of orthoptic exercises, that has made it possible to treat successfully the numerous cases of diplopia caused by the head injuries of the war.

The occurrence of diplopia

In peace time cases of traumatic diplopia are undoubtedly rare. In the Royal Air Force, where high spirited and not very prudent young men are apt to travel fast in aeroplanes or on motor cycles, the opportunities for acquiring a head injury might be expected to be greater than among the less mobile members of the community. Even so, not more than five or six airmen suffering from traumatic diplopia were seen in 1937-8.

It seems, therefore, that one of the reasons why the surgery of the vertical and oblique muscles of the eye has remained so undeveloped is the lack of opportunity most eye specialists have had for the diagnosis and treatment of traumatic diplopia; having little experience of the condition, and accepting the popular opinion that nothing can be done in these cases, they content themselves with prescribing prisms, or encouraging suppression of the false image by means of a frosted glass. How the war of 1914-18 did not lead to a review of the existing methods of treatment is not fully understood, for the heavy casualties from the western front must have included a great number of men suffering from head injuries, and many of them must have had double vision.

Ophthalmic services were not organised, however, to the same extent as in the recent war, and in France a great deal of eye surgery was done by general surgeons.

During the year 1942 to mid 1944 more than 200 cases of diplopia due to injury were seen at routine examinations in two service hospitals. It is not possible to say what percentage of the total head injuries this figure represents. Many men were wounded so seriously that they could not be examined and a number were transferred to other hospitals as soon as their general condition had sufficiently improved.

On the other hand, patients suffering from diplopia caused by head injuries received some months before (cases from overseas, etc.) were often referred to hospital for treatment.

A few cases were seen when they were sent for an opinion, on recurrence of symptoms after they had previously been passed fit for flying elsewhere. One pilot said that when he started to fly again, after a crash, he saw two runways on coming in to land, and in his confusion stalled an Oxford from 20 feet, and crashed again.

When discussing the incidence of traumatic diplopia it should be mentioned that it is often present in cases of trauma to the head and face, but this is frequently masked by other injuries, especially burns, or it may develop later owing to an injury to the orbit which forces a particular muscle to work at a mechanical disadvantage. Under these conditions, merely to maintain the eyes in their

primary positions will cause some discomfort and fatigue; moving the eyes in the direction of action of the paresed muscle will increase the fatigue until the " fusion hold " is strained to breaking point, and the object looked at splits in two.

Writing on this power of fusion, Bielschowsky[13] remarks that " the stronger the fusion mechanism, the longer and more easily it will keep the tendency to dissociated vertical movements latent." This is borne out by the history of many patients, particularly that of an R.A.F. policeman. This man suffered from 16 pd of right hyperphoria, but his power of fusion was such that he did not see double unless he went to the cinema. At his last visit he found he had to force his head further and further back, until eventually he had to shut one eye to overcome the diplopia. After one operation and orthoptic exercises, the hyperphoria was reduced to 8 pd. His eyes remained so comfortable and his power of fusion so strong that he considered further operation unnecessary.

The nature of diplopia

Traumatic diplopia may be divided into three categories :—

1. Diplopia caused by the alteration in the " seating " of the eye, and the mechanical embarrassment under which certain movements have to be made.
2. Diplopia due to injury of the muscles themselves by direct or indirect violence.
3. Diplopia due to a paralysis of an extra-ocular muscle, following damage to its motor nerve by intra-cranial injury.

Group 1 comprises those cases of facial fracture illustrated by case notes 1 to 9. These often result from aircraft accidents. A pilot tends to strike his head on the gunsight when he crashes, and fractures the middle third of his face, or the zygomatic malar complex.

In considering Group 2, direct injury to a particular muscle is a somewhat rare occurrence. It sometimes follows a frontal sinus operation or perforating injuries below the eye. (Cases 11, 13 and 16.)

Indirect violence is more difficult definitely to prove, but it is reasonable to suppose that the eye, suspended in the orbit in its cone of muscles, must suffer displacement when the skull receives a heavy blow. Ridley[14] puts forward the suggestion that the optic nerve is injured in this way through the eye-ball being " left behind " when the head is struck. It is thought that in a similar manner the eye muscles are contused, and diplopia, from the resulting paresis, is produced. The rapidity with which many of these cases recover lends colour to the view that there has been a minor injury to the muscle without coincident damage to the cranial nerve supply.

The extra-ocular muscles

Before any specific treatment can be undertaken, it is necessary as in other medical and surgical conditions, to make an accurate diagnosis. To understand which ocular muscle is at fault it is important to consider not so much the action of each separate muscle, as the binocular movements of the eyes, and the part which the several muscles play in relation to each other when these movements are made. The recti muscles which act in a horizontal direction have but one function, to rotate the eye about its vertical axis. When, however, the other muscles which act in vertical direction are considered, it will be seen that owing to their line of action being placed obliquely to the line of vision, each has a primary action about the horizontal axis, and subsidiary actions about the vertical and antero-posterior axes of the globe. The actions of the ocular muscles can therefore be tabulated as follows :—

	Primary action	*Secondary action*
Internal Rectus	Adduction	None
External Rectus	Abduction	None
Superior Rectus	Elevation	Internal rotation and intorsion
Inferior Rectus	Depression	Internal rotation and extorsion
Superior Oblique	Depression	External rotation and intorsion
Inferior Oblique	Elevation	External rotation and extorsion

The vertically acting muscles exert their maximum effect when the antero-posterior axis of the eye is in the same plane as the line of action of the muscle. Consequently, the superior and inferior recti act most strongly when the eye is rotated outwards, while the oblique muscles exert their maximum effect when the eye is turned inwards.

Krewson[15] writing on the actions of the oblique muscles, said "The planes of action of the two oblique muscles were said by Maddox to be identical, each making an angle of 51 degrees with the median plane." From corrected figures of Vockmann, however, the tendon of the superior oblique makes an angle with the median plane of 55 degrees 21′ while the inferior oblique muscle makes an angle of only 50 degrees 57′. This means that the inferior oblique has a greater vertical purchase on the globe than the superior oblique, *i.e.*, its plane of action is closer to the antero-posterior diameter. In fact, the inferior oblique is actually pulled more closely towards parallelism with the median plane by its check ligament, which pulls the muscle belly laterally. Thus the inferior oblique muscle contributes more of its energy to elevation than the superior oblique contributes to depression; the rate being 60-57 or 42 per cent. to 37 per cent. as indicated by Verrijp."[16]

These facts might account for the marked overaction of the

inferior oblique, which is often seen to occur when the superior rectus of the opposite side is paralysed, compared with the over-action of the superior oblique which follows a paralysis of the opposite inferior rectus.

Although individual muscles and their primary and subsidiary action must be described, it is necessary to emphasise that no ocular muscle acts alone. Normally they act in concert to maintain perfect ocular balance in whatever position they move the eyes.

The following are the muscles which are associated in the conjugate movements of the eyes, in the six diagnostic directions in which they exert their maximum mechanical power.

	Muscles whose action predominate	
Diagnostic directions	*Right eye*	*Left eye*
Right	External rectus	Internal rectus
Left	Internal rectus	External rectus
Upwards and right	Superior rectus	Inferior oblique
Upwards and left	Inferior oblique	Superior rectus
Downwards and right	Inferior rectus	Superior oblique
Downwards and left	Superior oblique	Inferior rectus

Each muscle of the above pair is known as the contralateral synergist of its partner, as are the two internal recti when the eyes converge. The homolateral vertical recti and obliques are direct antagonists of each other, while the superior and inferior recti are the indirect antagonists of the superior and inferior obliques respectively, of the same side.

Methods of diagnosis employed

From the point of view of surgery and orthoptics, identification of the affected muscle or muscles is essential for correct diagnosis and treatment. Such a statement may seem platitudinous, but it is a common experience to find that in many cases of diplopia the wrong muscles are incriminated.

The correct identification of the affected muscle is sometimes a matter of considerable difficulty, especially when secondary contracture of the direct antagonist of the same side has already occurred, leading to a relative paresis of the synergist of the other eye.

Speaking on the ocular palsies, Chavasse[11] said, " Not only are all of us free to form and express our opinions about a given case, but, and this is particularly democratic, the various opinions are allowed to have a most exhilarating diversity. If one authority says the right superior rectus is paralysed, we can be sure that another equally eminent will blame the left superior oblique." The sequence Chavasse had in mind was undoubtedly :—

1. A primary paralysis of the right superior rectus (with overaction of the left inferior oblique).
2. A secondary contracture of the right inferior rectus, leading to
3. A relative paralysis of the left superior oblique.

This sequence is often seen to follow, in a more marked degree, a primary paresis of the superior oblique and overaction of the opposite inferior rectus. With the lapse of time the inferior oblique of the same side undergoes a secondary contraction, causing a relative paresis of the opposite superior rectus. This overaction of the inferior oblique may be due in part to the anatomical arrangement of its line of action and of its check ligament, both of which peculiarities have already been mentioned. From the history of the accident it is often possible to determine into which of the three different categories the particular case will fall. The double vision which follows a frontal sinus operation will usually correctly suggest a paresis of the superior oblique of the same side.

Case 7 will illustrate the significance of the proper history. This pilot presented himself with the story that he had asked his medical officer if he could have his eyes " checked up " because he noticed that after one or two drinks he began to see double. This had never happened to him before, and he thought it would be a good thing to go along to the " Doc." He was seen by his doctor, who referred him for disposal and treatment.

The patient had a slight scar on his eyebrow and slight ptosis of the left upper lid; apart from that there was nothing unusual about his appearance. On being asked if his head had been injured recently, he said he had received a slight " bang " on the head three months ago, but thought that he had quite recovered. On taking a more complete history, it was revealed that this pilot had been shot down near the Dutch frontier, and crashing in a turnip field he had struck his head on the gunsight of his Mustang. He had treated his cut face himself, and had made what he considered to be a complete recovery. X-Ray revealed a fracture of the zygomatic malar complex with a relative paresis of the left inferior oblique and left internal rectus muscles. The history of the injury (whenever it is possible to elicit one) will, therefore, often help considerably in distinguishing to which group the case belongs.

The nature of the diplopia, whether it is horizontal or vertical in character, crossed or homonymous, will also indicate which movement of the eyes causes the greatest separation of the images, and this particular movement can be carefully watched during the next part of the investigation, which is the observation of the ocular movements.

Observations of the ocular movements

With care it is possible to make two observations during the examination of the ocular movements:—

1. The limitation of movement of the affected eye.
2. The overaction, during the same movement, of the sound eye.

It is not always possible to observe any limitation of movement in the direction of action of a paresed muscle. If, however, the sound eye is covered, the overaction of this eye, or the secondary deviation, often will be clearly demonstrable.

Chavasse[11] has pointed out that paralysis of an extra-ocular muscle results in overaction of the synergic muscle in the other eye. For example, an "upshoot" of the right eye which is found to occur when the eyes are directed upwards and to the left, means that the left superior rectus is partially or completely paralysed. Therefore, by this means alone, it is often possible to identify the paresed or paralysed muscle.

Since the nervous energy which is called upon to activate the paralysed muscle is also conducted to the contralateral synergist (Hering's law), the movement of the paralysed eye being less than its fellow, the image of that eye will be projected into space in the direction of action of the paralysed muscle, and farther away than the true image. Consequently, when the ocular movements are made, the diplopia will be found to be greatest in the direction of action of the paralysed or paresed muscle, and the more displaced image will be found to belong to the affected eye.

If the diplopia is horizontal in type, an object such as a pencil is moved from the midline, first to the left and then to the right; if an adductor muscle is at fault, a crossed diplopia will occur, while if an abductor is affected there will be an homonymous diplopia, more marked on the affected side.

In the case of vertical diplopia, the four positions where there is maximum action of the particular vertical muscles are examined. Namely, upwards to the right, upwards to the left, downwards to the right and downwards to the left. To identify the affected muscle it is necessary to find out where the greatest separation of images occurs. By covering and uncovering one eye it is possible to determine quickly to which eye the "farther away" image, or false image, belongs. If this image is shadowy and difficult for the patient to see, the red/green diplopia test is carried out. This is the same in essentials as that described above, except that by means of red/green goggles and a bar of light, a red image can be presented to the right eye and a green image to the left eye. The light is moved into the same six diagnostic positions, the

examiner noting where the maximum horizontal and vertical diplopia occurs.

The muscle which is affected when the diplopia is greatest in a certain position may be tabulated thus:—

1. Diplopia—horizontal.

(*a*) Maximum separation of image looking to the right.

Further image belonging to right eye—paralysis of right external rectus.

Further image belonging to left eye—paralysis of left internal rectus.

(*b*) Maximum separation of images looking to the left.

Further image belonging to left eye—paralysis of left external rectus.

Further image belonging to right eye—paralysis of right internal rectus.

2. Diplopia—vertical.

(*a*) Maximum separation of images upwards and to the right.

Higher image belonging to right eye—paralysis of right superior rectus.

Higher image belonging to left eye—paralysis of left inferior oblique.

(*b*) Maximum separation of images upwards and to the left.

Higher image belonging to left eye—paralysis of left superior rectus.

Higher image belonging to right eye—paralysis of right inferior oblique.

(*c*) Maximum separation of images downwards and to the right.

Lower image belonging to the right eye—paralysis of right inferior rectus.

Lower image belonging to left eye—paralysis of left superior oblique.

(*d*) Maximum separation of images downwards and to the left.

Lower image belonging to left eye—paralysis of left inferior rectus.

Lower image belonging to right eye—paralysis of right superior oblique.

Measurement of the diplopia

The muscle or muscles at fault having been diagnosed, it is now necessary to measure the amount of the diplopia in order—

1. to be able to observe any recovery that may be taking place;
2. to assess the results of treatment.

To do this, the following methods are employed:—

(*a*) The Maddox rod.

(*b*) The Hess screen.

(*c*) The synoptophore.

The Maddox rod. It is useful, particularly during wartime, not to have to rely on elaborate equipment, and it has been found that the estimation of diplopia by the Maddox rod is simple and accurate. By means of the Maddox rod the spot light seen by one eye is presented to the other as a red line of light, and the amount of horizontal and vertical separation can be measured on the tangent scale or in prism dioptres.

The Hess screen. In essentials, this is a dissociation test, one eye seeing the red dots through a red glass, and the other the green pointer through a green glass. With the green glass before the affected eye, the pointer will be placed inside the red dots, when the eye is looking in the line of action of the paralysed muscle; the reverse will be the case when the green glass is placed before the unaffected eye. The primary deviation of the paralysed eye and the secondary deviation of the sound eye can both be charted, and the amount of recovery, either spontaneous or as a result of treatment, can be accurately assessed.

The synoptophore. Finally, the eyes of each patient suffering from diplopia are tested on the synoptophore. The angle of deviation is measured, ahead and on side movements. Slides of dissimilar objects are used to measure the " simultaneous perception angle," and slides of similar objects are used for testing the angle of fusion. The duction power of the eyes is then measured, adduction, abduction and torsion are usually recorded in degrees and height in prism dioptres. Finally, an assessment is made of the stereoscopic vision.

Treatment

When a man, after being wounded or injured in the head, becomes sufficiently aware of his surroundings to notice that he is seeing double, even although the diplopia occurs only in certain positions of the eyes, stereoscopic films of the head in the vertico-mental position should be taken, in order to be sure that there is no bony injury of the walls of the orbit. An ordinary X-Ray picture taken in the " AP " position frequently will not show any deformation of the bones. Case No. 2 illustrates the ease with which these fractures can be missed. An X-Ray report was requested on . . . (1) the left ankle, (2) the skull. The report stated (1) fracture of internal malleolus with marked medial displacement of lower fragment. (2) No fracture seen on these films.

The surgeon later, on clinical findings, asked for stereoscopic films of the face for ? middle third fracture. The following is the X-Ray report : " Appears to be some depression of the left orbital floor, with separation of the fronto-malar suture. Left maxillary antrum is obscured presumably by blood clot." This case was

complicated by severe burns, and initially the swelling of the soft tissues closed the eyes and effectively obscured the bony land marks.

(A) *Restoration of the normal anatomy of the parts.* Frontal blows such as pilots commonly receive when attempting a crash landing may be transmitted through the nasal arch and the ethmoids to the maxilla and the bony walls of the orbit; they result in middle third fractures of the face and are often the cause of diplopia.

The involvement of the orbit can be diagnosed before the onset of swelling, by palpation of the orbital margin which will often reveal a gap in the neighbourhood of the malar maxillary suture.

The treatment lies in the hands of the facio-maxillary unit, and consists in the reduction of the fracture and the fixing of the fragments by anchoring them to the teeth or skull. The middle third fractures of the face comprise, in the first place, the malar fracture, and secondly what Mathews[17] calls the fractures of the malar maxillary complex. If seen within nine or ten days of the injury, malar dislocations can be levered back into position; if left longer, open operation and wiring of the fronto-malar processes will usually be necessary (Case 52). Fractures of the malar maxillary complex run across the outer wall and floor of the orbit to the anterior surface of the maxilla, and the malar is frequently telescoped downwards, backwards and inwards towards the maxillary antrum. The separation of the malar from the external angular process of the frontal can usually be felt, as well as the step deformity in the infra-orbital ridge, if the extensive swelling of the soft tissues has not already obliterated the bony landmarks and closed the lids.

The diplopia which results from the displacement or loss of the orbital floor may not indeed be noticed by the patient before his lids are closed by the swelling of the surrounding tissues (Case 2).

The treatment consists in raising the orbital floor by packing the antrum; this is done with 1″ ribbon gauze until the pupil on the affected side is slightly higher than its fellow (Case 4).

If immediate restoration of the floor of the orbit is not effected shortly after the injury, it may be advisable in severe cases to remake the orbital floor by the insertion of a bone graft taken from the inner table of the iliac crest (Cases 4 and 5).

When the displacement has been reduced, as far as possible by these means, the residual diplopia can be dealt with by a shortening or lengthening operation on the extra-ocular muscles.

(B) *Orthoptic Treatment.* Before the surgical correction of these cases is undertaken, however, a careful investigation of the diplopia is made along the lines already described, and orthoptic

treatment is begun. The orthoptist measures each case and, if the degree of the diplopia is small and the fusion hold is good, continues with the treatment in order to increase the duction power and help the ocular rehabilitation of the patient. After operation, orthoptic exercises are again given to stabilise the binocular reflexes in the new position of the eyes.

In dealing with head injury cases, a special understanding, which is partly innate and partly bred of experience, is invaluable in treating not only the paresis of the ocular muscles, but in fanning the flames of hope and self confidence, which in many of these cases tend to burn so low (Cases 11 and 41).

A number of patients tend to make a spontaneous recovery, but in the opinion of R.A.F. ophthalmologists orthoptic exercises judiciously given cut short the period of convalescence and constitute a very valuable therapeutic measure. Many others who have made what is considered to be a good recovery, without any orthoptic treatment, are left with a residual weakness. This often causes ocular discomfort and is only partly overcome by the adoption of a head tilt. In times of nervous stress or prolonged ocular fatigue the binocular hold may be strained to the point of disruption, and diplopia results (Case 7).

(C) *Operative Measures.* Operation is not considered until five or six months have elapsed since the date of injury. Surgical adjustment of one or more of the extra-ocular muscles is then carried out, preceded and followed by orthoptic exercises. In the more pronounced cases it is usually obvious from the beginning that operative measures will have to be undertaken, and the orthoptist will quickly know if further improvement is likely to occur. In these cases it would appear that it is better to operate before a secondary contracture of the homolateral antagonist occurs and complicates the picture by producing a relative paresis of its contralateral synergist. One of the advantages of the Hess screen is the graphic way in which these secondary contractions can be charted.

Many operative procedures are possible, and may be considered successful if judged in terms of ocular comfort and the disappearance of the diplopia in the primary position of the eyes. In the case of operational pilots, however, this is not enough. A fighter pilot, who has to fly by day and night, has continually to search the sky for enemy aircraft, and must have no diplopia in any part of his visual field. It is thought, therefore, that the standards of cure in this series are high, when after treatment the particular subject has been passed fit for flying by the Central Board of the R.A.F. and satisfactory when, as in the case of non-flying men, they have returned to duty with no symptoms and no double vision in the normal position of the eyes.

Ordinarily the twelve extra-ocular muscles of the eyes work together in harmony, to maintain binocular single vision. When one or more muscles are affected the binocular machine is unbalanced and of the operations which are performed to correct the diplopia, those which equalise the balance of power in the line of action of the paralysed or paresed muscle are obviously a better mechanical solution that those which are planned to adjust it in a line directed diagonally to the line of action of the affected muscle. The recession of the contralateral synergist is, therefore, an operation which has mechanical advantages over a weakening or lengthening operation of the direct antagonist of the same side. This operation is to be preferred, however, if there has been a secondary contraction of a direct antagonist, not because it is the antagonist of the muscle primarily affected, but because it is the contralateral synergist of the muscle in the other eye which is relatively paresed. The other reason for weakening the direct antagonist is when the unopposed torsional power of the muscle is producing a marked cyclophoria.

Case 32 illustrates the degree of excyclophoria which resulted from a relatively mild paresis of the right superior oblique. The patient complained that the tilting of the images worried him far more than the vertical displacement. The overacting inferior oblique was tenotomised with the result that the excyclophoria was reduced by half (from 10 prism dioptres to 5) and his subjective symptoms greatly improved. Case 49 is another example of the worrying effect which the tilting of the image had upon the patient. Two operations were performed upon the eye muscles with apparent success. Two months later he complained that he began to see double again after working for two hours (he was an engine fitter). The false image appeared first of all to tilt, and then to separate. After the excyclophoria had been surgically corrected discomfort disappeared and he became ocularly fit for aircrew duties.

In the smaller degrees of vertical diplopia, Lyle[18] advocates a controlled tenotomy of the superior or inferior rectus muscle. By means of a light placed above the patient's head, and a Maddox rod held before his affected eye, the muscle can be cut in three places and allowed to stretch until the red line passes through the light. The operation has been done twice only in this series (Cases 31 and 46). On the third occasion on which it might have been performed, the muscle, in this case the inferior rectus, was recessed. There was no bleeding, and after the recession the gap between the old insertion and the new was no more than 1 to 1½ mm. This corrected 2 prism dioptres only of hypotropia (ahead) and completely abolished the troublesome diplopia which the patient

experienced on reading or walking down stairs, due to the marked overaction of the muscle. The difficulties which have been experienced with these so called controlled tenotomies seem to be due to a lack of continued control, although the immediate result may appear to be satisfactory. This it is thought is caused by :—

1. The premedication.
2. The dilatation of the pupil (cocaine).
3. The haemorrhage from the cut vessels.

In (1) the patient seems to find it difficult to localise the red line in relation to the light; (2) the wide pupil does not assist in making a nice judgment possible. (3) The haemorrhage, even though small in amount, seems to congeal and subsequently to contract; this anchors the muscle and the organising clot eventually draws it up again. This is more likely to occur if the muscle is the superior rectus, since the eyes when bandaged tend to move upwards and slightly outwards. Orthoptic exercises will in great measure counteract this tendency; a small bloodless recession, however, obviates the difficulty and should, in the author's view, be done first.

In Case No. 31 the overaction of the superior rectus was corrected by a three snip tenotomy controlled on the table by a Maddox rod, but within a week the hypertropia was a little greater than before the operation (*i.e.*, 3 P.D.). A two millimetre recession was then carried out with a satisfactory result; (vide Hess chart) the operation was, however, slightly more difficult and less bloodless owing to the previous reaction.

In dealing with an overaction of the inferior oblique, White in America has advocated a recession of the tendon at its attachment to the globe.[19] The operations carried out in this series of cases have been of two types, (1) a tenectomy (rarely a tenotomy) of the inferior oblique near the origin of the muscle, and (2) a tenotomy of the muscle near its insertion to the globe. The good results obtained from very varying degrees of overaction of the muscle, seem in the first method due to not anchoring the muscle tendon in a fixed position. The conjunctiva is not opened, and the muscle slides along the floor of the orbit to take up a position in harmony with the other extra-ocular muscles, particularly its yoke muscle of the other side, *i.e.*, the contralateral synergist. To enable this to occur while the muscle is still in a plastic condition the eye pads are removed, the next day if possible, and the eyes balanced with fusion pictures on the synoptophore. A tenotomy near the insertion of the muscle is more drastic and seems more suitable for the higher degrees of overaction, particularly when the results of the first method have proved inadequate.

A striking example of this is afforded by Case No. 53. The

subject was a pilot who had crashed in Germany and owing to a paresis of the right superior oblique, had suffered from constant diplopia during the three years he had been a prisoner of war. During the time he spent in captivity in Stalag Luft. III he developed a certain amount of suppression of vision in the left eye, a head tilt to the right, and a secondary paresis of the right superior rectus. On his return to England he was admitted to hospital suffering from diplopia. When the eyes were relaxed there was a gross overaction of both the right inferior rectus, and the left inferior oblique (L/R 26△, 20° to the R.). Accordingly a generous tenectomy of the left inferior oblique and a recession of the right inferior rectus was carried out. Four weeks later there was still considerable overaction of both muscles (L/R 17△, 20° to the R.). The right inferior rectus was accordingly again exposed (L/R 25△ relaxed), completely freed and tenotomised. At operation there was found to be no pull by the muscle, and the picture which presented itself was more one of generalised thickening and contracture round the muscle itself. Even after this operation there was still the overaction of the left inferior oblique to deal with, and this muscle had already been thoroughly tenectomised near its origin (L/R 8△, Excyclophoria 6°).

The other end of the muscle was therefore exposed and tenotomised near the globe. By this operation the excyclophoria was eliminated, and the hyperphoria reduced to zero straight ahead, and L/R 4△, 20° to the R.

It may be seen that either end of the inferior oblique is readily accessible, and that it sometimes is advantageous, as in this instance, to adopt the alternative method of approach.

The superior oblique muscle is not infrequently paralysed or paresed following a direct injury in the region of the pulley (Cases Nos. 15 and 38) or indirectly following a lesion of the fourth cranial nerve. The surgical treatment is a recession of the contralateral inferior rectus. Landolt[9] advanced the inferior rectus of the same side, but this is not as satisfactory as the former operation, for the following reason: Besides the limitation of depression of the affected eye there is also some extorsion present, owing to the paresis of its secondary action which is that of intorsion. If, now, the inferior rectus of the same side is advanced, the vertical diplopia will undoubtedly be improved, but even if the obliquity of the new position is adjusted, the torsional diplopia will be aggravated, since the secondary action of the inferior rectus is that of extorsion. In regard to an overaction of the superior oblique, it must be remarked that this is a very rare condition, and its treatment by surgical means seems to be rarer still.

As a result of a crash in a twin-engine bomber the supra-orbital

margin of the left frontal bone of the air gunner described in Case 1 was fractured, and the trochlea displaced; the new position of the tendon of the superior oblique allowed the muscle grossly to overact. This caused a very troublesome diplopia when looking down, and an attempt was made to correct the overaction by lengthening the tendon of the oblique between the pulley and the globe. (Cross.) The operation did not reduce the amount of vertical diplopia, but it did reduce the incomitance so that the Hess screen showed the paresis now to be affecting more the left inferior oblique, with overaction of the right superior rectus. By means of a 3 mm. recession this overaction was satisfactorily reduced and the diplopia abolished except on high dextro-elevation of the eyes.

In connection with the surgery of the superior oblique about which little has been written in this country, it may prove of interest to recount the series of untoward incidents which befell both the writer and a patient who was admitted to hospital on account of inability to maintain single vision when using his reflector gunsight. Trauma could not be held entirely responsible for the condition, and although on a number of occasions this officer (an Irishman) had suffered from a series of minor injuries, it was thought that basically the trouble was caused by a congenital weakness of the left inferior rectus, or ? birth injury. When during his training he looked through his reflector sight in order to bring his guns to bear upon the drogue, he found it impossible to sight the target unless he closed one eye. This became increasingly noticeable if he was diving, and had to look into the sky above him: on examination he was found to have diplopia to the left, above and below eye level, particularly when looking down. There was gross overaction of the right superior oblique, paresis of the left inferior rectus and marked overaction of the left superior rectus. The first operation, namely a recession of the left superior rectus, lessened the diplopia up and to the left, but made practically no difference to the double vision experienced in the lower temporal field. Encouraged by the successful outcome of the surgical adjustment of the inferior oblique at its insertion to the globe, the improvement brought about by Cross in a similar case by splitting and lengthening the tendon of the superior oblique between the trochlea and the eyeball, and by White's description of the feasibility and practical utility of recessing the superior oblique, a lengthening operation on this muscle was undertaken. The right superior rectus was divided and reflected; the superior oblique exposed, divided and lengthened near its insertion to the globe, the superior rectus was then reattached to its insertion and the conjunctiva closed.

This operation can only be described as being disastrous in its outcome. The superior oblique apparently became adherent to the overlying superior rectus and the incyclophoria which resulted was both extraordinary and alarming. A third operation was carried out to free the adhesions, and the retaining catgut suture completely removed. Improvement resulted, but after a while, owing to the unopposed action of the superior oblique, 3 degrees of excyclophoria occurred whenever the eyes were turned to the right. The false image rose and twisted, the torsion being greater in degree and causing more discomfort than the slight vertical displacement of 2 P.D. "Clip on" prisms which enabled the patient to read in rather more than less comfort were prescribed to adjust the vertical component of the imbalance, and the patient sent on sick leave to enable the condition to stabilise sufficiently for a final adjustment to be made.

On his return to hospital the right inferior oblique was tenotomised only, and following a course of orthoptic exercises which were started the following day, the excyclophoria was eliminated.

The whole story, although it has a happy ending, had during its unfolding its chequered and dramatic moments. However, the practice evolved by Lyle and Cross in 1941, in which a recession or lengthening of the overacting synergist is employed to adjust the imbalance caused by a paresis of an extra-ocular muscle, is still upheld, and this case must be looked upon very definitely as the exception which proves the rule. (The case is described in detail in Case Records, No. 55.)

The correction of a diplopia due to a paresed vertical muscle, by attempting to strengthen it mechanically by means of a shortening operation is difficult to judge; the amount of the advancement cannot be accurately estimated owing to the variation in the amount of the paresis, and the amplitude of fusion will not compensate for a residual imbalance to the same degree as in a horizontal diplopia. Even an advancement of the synergist of the same side is not entirely satisfactory, although Stanculeanu[8] has reported that an advancement of the right inferior rectus, in cases where the right superior oblique has been paralysed, has given satisfactory results. In those cases of paresis of the lateral recti, a recession of the overacting muscle of the opposite side seems to balance the extra-ocular muscles better, and to interfere less with the mobility of the eyes than operations designed to increase the leverage effect of the paresed muscle.

Case 44 is an example of a paresis of the left external rectus which was still present 18 months after a bomb injury. There was no binocular vision when examined on the Bishop Harman diaphragm test, and a lateral excursion of 15 degrees only in the

left eye; binocularly there was marked overaction of the right internal rectus when the patient was looking to the left, with immediate diplopia. The right internal rectus was recessed, and the patient was discharged, holding his head straight, maintaining binocular single vision, and suffering from no symptoms except on extreme laevo-version. This seemed to be a very satisfactory result, until 7 months later when the patient was readmitted to hospital suffering from headaches and a recurrence of the diplopia. The left internal rectus was recessed and subsequently the leverage of the right internal rectus was again reduced. It is interesting to note that the power of adduction compared with the previous figure of 25 degrees, was not impaired by these proceedings, and that orthoptic treatment to reinforce the binocular reflexes was given before and after each surgical operation. On discharge from hospital this airman's symptoms were completely relieved and, some 18 months later, had not returned.

In dealing with a complete paralysis of the external rectus, it is possible not only to straighten the eye, but to obtain a fair range of lateral movement by the method originated by Hummelsheim, but more often associated with the name of O'Connor. On general principles Cross considered that recovery from the injury might, in the early months, be aided by reducing the drag on the paralysed muscle by means of a recession of the homolateral antagonist. This contention, although undoubtedly sound in theory, could not in practice be substantiated, as in the three cases so treated in hospital the external rectus remained completely paralysed. For the result illustrated in Case No. 55, an advancement and resection of the paralysed muscle was carried out, and equal strips were taken from the vertically acting recti and attached to its insertion; in addition to the internal rectus of the same side, which had been recessed some five months previously, the internal rectus of the opposite side was similarly dealt with and the ultimate range of external movement increased to 15 degrees. It seems important to take strips of equal width and length from the muscles above and below. In one case where unequal strips were taken to overcome a vertical imbalance which was also present, a troublesome hypertropia developed when the eyes were turned to the affected side. Subsequent operations for the correction of this hypertropia resulted in the loss of the extra lateral movement which had previously been obtained but had been associated with a vertical tropia.

A muscle may be looked upon as a lever of the third degree with power acting between the fixed point, or fulcrum, and the weight to be moved. From the above description it may be seen

that the surgical measures that have proved most efficacious may, in their order of priority, be listed as follows:—

1. Reduce the leverage of
   - (i) the synergist of the opposite side;
   - (ii) the direct antagonist of the same side;
   - (iii) the indirect antagonist of the same side;
   - (iv) the corresponding muscle of the opposite side.

   The required effect may be produced by:—
   - (*a*) A recession of the muscle tendon.
   - (*b*) A tenotomy or tenectomy.
   - (*c*) A three snip extension of the tendon.
2. Increase the leverage of
   - (i) the paresed muscle;
   - (ii) the synergist of the same side.

   The required effect may be produced by:—
   - (*a*) An advancement of the muscle.
   - (*b*) An advancement and resection.

Since the advanced muscle will undoubtedly adhere to the globe at the site of its original insertion, from a mechanical point of view it will have the same effect as a resection.

Particular care must be taken to avoid over-correction, but if this occurs the same procedure is adopted; the primarily affected muscle now taking the place of the contralateral synergist which, on account of the mechanical interference, may be considered to be suffering from a relative paresis.

The corresponding operations are therefore:—

	For under-correction	For over-correction
The reduction of the leverage.	The contralateral synergist.	The paresed muscle.
The reduction of the leverage.	The direct antagonist of the same side.	The indirect antagonist of the opposite side.
The reduction of the leverage.	The corresponding muscle of opposite eye.	The synergist of the same side.
The increase in the leverage.	The synergist of the same side.	The corresponding muscle of the opposite side.

Here, it may be advocated that when, owing to secondary contracture, there is an overaction of the inferior oblique as the direct antagonist of the same side, as well as the opposite inferior rectus as the contralateral synergist, the inferior oblique should be dealt with first, and the final adjustment carried out on the vertical rectus. For example, following a paresis of the right superior oblique, a contracture of the direct antagonist, the right inferior oblique may have taken place. Before the operation of the contralateral synergist (the left inferior rectus) is dealt with, it is

advisable to perform a tenectomy of the right inferior oblique, and to adjust the residual imbalance by a recession or a three-snip tenotomy of the left inferior rectus at a later date.

Finally, it may perhaps be emphasised that in the writer's experience gentleness and the arrest of haemorrhage are two factors which, without putting too high a tax on time, definitely repay the surgeon and hasten convalescence. By preventing blood clot and adhesions forming at the site of the operation the mobility and surgical adjustment of the eye is unlikely to be upset by subsequent contraction.

As in a game one plays for a leave, the surgeon in these matters endeavours to be well placed for the winning stroke, lest perchance the accuracy of his former efforts has not achieved finality.

The different types of injury, the methods of treatment and the results obtained are given in Tables I and II.

Twelve typical case histories of traumatic diplopia have been selected and one congenital case included as affording a good example of the outcome of surgical adjustment of an overacting superior oblique muscle. These form an appendix to this paper.

Analysis of cases

The cases have been divided into three main categories, according to the part affected by the injury. Some of the cases fall naturally into their appropriate classes; others, in which the damage has been more widespread, properly belong to more than one group. A consideration of the history, the course and the final disposal has, however, usually been sufficient to determine to which group the case belongs. To take a concomitant concussion as an indication of nerve injury is often misleading and inconclusive. Aldren Turner[20] writing on the indirect injuries of the optic nerve says " considerable damage can be done to the intracranial structures without the general cerebral disturbance which results in concussion, a fact equally true of the brain itself where extensive damage can be inflicted without loss of consciousness, when the impact is from an object of small size, such as a bomb fragment or a piece of masonry."

Case 37 illustrates, somewhat dramatically, the transitory nature of a concussion, which was followed by a lesion of the mid-brain. The airman described was flung out of an aeroplane, striking his head as he fell against some part of the aircraft. This initiated a lesion in the mid-brain which later caused diplopia and a transient paralysis of the legs. He could not have been unconscious for many seconds, since he effectively pulled the rip cord of his parachute and made a satisfactory landing. On the other hand, the patient described in Case 4 was unconscious for 12

hours, although subsequent examination showed that the left orbital floor, and not the intracranial contents, had suffered the greater damage.

From an analysis of these cases it appears that a post traumatic diplopia is more often the result of intra-orbital than of intracranial injury; with this view Gross[21] is in agreement. Many cases that have made a "spontaneous" recovery have a residual weakness of the previously affected muscle. Others are left with a troublesome, and often in the case of air crew, a disabling diplopia, which is more marked in certain positions of the eyes.

In three cases of the series, immediate treament was given to restore the normal anatomy of the parts. In Case 4 the antrum was packed in order to maintain the elevation of the floor of the orbit.

In Cases 3 and 52 the malar was wired. See Table II. Patients with head and maybe other injuries are usually attended first by a general surgeon who is often more exercised by considerations affecting concussion and general injuries, than by thoughts of diplopia and its possible treatment. Only three patients, therefore, in group I received immediate treatment for the fractures involving the orbits, and many of the cases had, it appeared, been overlooked altogether (*e.g.*, Case 6, Table II). To do this as has been explained already, is very easy, unless the possibility of a mid-face fracture is borne in mind and stereoscopic X-Ray pictures, in the vertico-mental position, are taken.

As regards the late treatment of these cases, two patients (Cases 4 and 5, Table II) received at the plastic centre a bone inlay from the crest of the ilium, to raise the floor of the orbit (Photo. Case No. 5), and the others, except in cases of refusal, or gross damage to the central nervous system, were satisfactorily treated by orthoptic exercises and surgical adjustments of the extra-ocular muscles.

The attached Table I shows the muscle or muscles that were affected, and those that were adjusted in order that diplopia might be eliminated over the widest range of ocular movement. The Maddox rod readings at 6 metres, before and after operation, have been given with the subject looking straight ahead. These would appear to be more graphic and concise that the synoptophore readings which are included in the records of each case.

Eleven patients were treated with orthoptic exercises alone; of this number six were pilots and one was a navigator. The six pilots all returned to flying, but the navigator, who would not consent to an operation, could not be sent back to flying on account of a residual imbalance. The six pilots, in spite of making a good "spontaneous" recovery, had a residual weakness which

made it difficult for them to continue with their flying duties. The fact that orthoptic exercises cured their symptoms and enabled them to return to flying, cannot be denied. For that reason such exercises, when given by an orthoptist with experience of the service, must be considered a valuable form of treatment, and one that can be relied upon, not only to re-educate the ocular muscles, but to improve the whole outlook of the patient.

In all the other cases the synoptophore has been used before and after operation, both to check the measurements of the case, and to strengthen by carefully graduated exercises the binocular reflexes.

Of the 50 extra-ocular muscles which were adjusted, 28 operations were performed upon the contralateral synergist or agonist, and 14 upon the direct antagonist of the same eye. On six occasions the corresponding muscle of the opposite side was adjusted, and other operations numbered two; in one of these the paresed muscle itself was advanced; this procedure was found to be unsatisfactory and on that account was not repeated, except in the O'Connor's operation, where the affected muscle was completely paralysed. (See photograph, Case No. 54.)

The incidence of single and double muscle paresis is shown in this series of 54 cases, in the tables A and B.

TABLE A.

Paresis of a single muscle.

	Superior rectus	Superior oblique	Inferior rectus	External rectus
Right	4	14	2	1
Left	10	3	0	1

TABLE B

Paresis of two muscles.

	Elevators	Depressors	External recti	Internal recti
Right	4	1	2	2
Left	4	1		

It may be seen that, taking the numbers together, the muscles most often affected are those which lie under the roof of the orbit, and act in a vertical direction. White and Brown[22] writing in the Archives of Ophthalmology on the occurrence of vertical anomalies, say that in a study of 11,600 persons, 715 had a vertical anomaly, and of the single muscles, the superior rectus was the muscle most affected. It is not surprising therefore, that in cases of injury to the head, the superior rectus should be the muscle which is found to be the one which is most often paresed. The fact that the inner edge of the superior rectus separates itself from the rest of the muscle relatively late in development, to form the levator palpebrae superioris, may

account for the constitutional weakness of the muscle, which shows itself as a paresis when the other muscles, supplied by the third nerve, escape.[12] Cross[21] in a survey of the causes of diplopia at a Military Hospital for head injuries, found that in 138 cases the extra-ocular muscles were affected in the following order: superior rectus, 24 per cent.; superior oblique, 21·5 per cent.; external rectus, 11 per cent.; inferior oblique, 6 per cent.; internal rectus, 5 per cent. and inferior rectus, 2 per cent. Various combinations of muscles accounted for the remaining percentage.

It may be seen therefore, from an analysis of these injuries, that of the cases that eventually need surgical measures for their correction, by far the greater number will need to have adjustments made to the vertically rather than to the horizontally acting muscles.

Results

One marine and nine members of the army were treated by the methods described; of these, seven returned to duty and two were invalided from the service, one for neuropsychiatric reasons, and the other for persistent diplopia for which he would have no operative treatment. Of the remaining 44 cases, 18 belonged to the ground staff of the Royal Air Force, and 26 were flying men. Of the ground staff, all returned to work with binocular vision, and no ocular symptoms. There was one exception, a girl engaged on precision work in the Women's Auxiliary Air Force. This girl had met with a severe head injury, which had resulted in a paralysis of the third and seventh cranial nerves. Although after operation she had no diplopia when looking straight ahead, and pluckily returned to duty for five months, she found the work too much for her, and was invalided from the service.

Of the 26 flying men, two later underwent hospital treatment for other injuries, two were treated at rehabilitation centres, one was invalided from the service on account of his head injuries, and one, an ex prisoner-of-war, was released from the Royal Air Force after his diplopia had been successfully treated. Two others were repatriated to the Dominions, and three regraded in a non-flying capacity on account of their nervous condition (both organic and functional) following their injuries. The remaining 15 returned to flying duties; these comprised four members of air crew, and 11 pilots.

Of the total number 73 per cent. returned to duty and 57·6 per cent. of the aircrew are known to have resumed flying. From an ocular point of view, several others are known to be fit for flying, but owing to various causes, such as being repatriated to their own country, it has not been possible to determine their

ultimate disposal. Although the estimate is a conservative one, it is thought that these figures show a distinct advance over the "expectant" method of treatment, with its two alternatives of prisms or a frosted glass.

Conclusions

This dissertation is, in its essentials, an apologia for the active and more radical treatment of the diplopia, which has been shown to be a not infrequent result of an injury to the head or face.

Owing to conditions of war, the incidence of diplopia following such injuries has risen steeply, and whereas before the war there was no recognised technique for the treatment of these cases, such a technique has now been worked out and is described in this thesis.

Similar cases collected before the war indicate that the condition will, with the advent of peace, continue to be a problem, when the complicated mechanisms of modern times again become responsible for the safety of so many of our journeys.

The methods of diagnosis and treatment which are advocated have now been well tested, and a medical board has in the case of pilots and air crews, assessed the results in relationships to the high standards of muscle balance which are required in the Royal Air Force.

When dealing with the vertically acting muscles it is, however, not necessary to obtain orthophoria in order to relieve effectively the most nauseating and distressing of symptoms, namely those of constant diplopia. Once the vertical deviation has been reduced by operation to manageable proportions, the binocular reflexes, strengthened by orthoptic training, will enable fusion to be maintained within the range of normal ocular movement. If the deviation is considerable the correction should be carried out in stages, rather than risk over-correction and another relative paresis which may well prove more troublesome both to the patient and to the operator than the first. By the aid of the Hess screen and synoptophore readings, the progress made with orthoptic exercises while the muscles are still in a malleable condition, can be watched and a second operation can, if necessary, be planned to correct any residual defect.

Experience has shown that it is rare to find a complete paralysis of a muscle following a head injury; usually it is a muscular paresis which causes the diplopia, and this more often follows a "closed" injury than a penetrating head wound.

In addition to the blurred vision and the mental confusion which the diplopia produces, there is usually an associated headache from the constant strain of trying, in some position of the

head and eyes, to fuse the images and obtain the relief of single vision. To be told that nothing can be done for him tends to deepen a patient's depression (vide Case 2) and cause neurotic symptoms to be superimposed upon his physical state. It is in these cases that so much can be effected by the treatment towards the mental as well as the physical rehabilitation of the patient. If operation has eventually to be performed, orthoptic exercises will prevent suppression in the affected eye and maintain during the waiting period the morale of the patient, as well as the tone of the extra-ocular muscles. After operation the exercises will strengthen the binocular reflexes and increase, while the eyes are still in a plastic condition, the fusion hold of the newly restored binocular vision.

The successful results of the treatment described are shown in the case records themselves in the analysis of the diplopia and in the methods used to overcome it.

The object of the work is to show that such treatment is reasonable in theory and sound in practice, and it is hoped that with a wider recognition of the possibilities of treatment, others may find relief and be restored again to a full life and binocular single vision.

Summary

1. Traumatic diplopia is not an uncommon sequel to a head injury.
2. Diplopia is caused usually by a paresis and not a paralysis of an extra-ocular muscle.
3. In the majority of cases, the " closed " head injury, and not the penetrating head wound, is the cause of diplopia.
4. The vertically acting muscles are most often affected.
5. Injuries to the orbit tend to be overlooked owing to the severity of other injuries, or masked by the swelling of the surrounding tissues.
6. The X-Ray diagnosis of fractures of the floor of the orbit is difficult to make, unless stereoscopic pictures are taken in the vertico-mental position of the head.
7. In fractures involving the orbit, the restoration of the normal anatomy of the parts is of immediate importance.
8. The orbital floor can be built up by means of a bone inlay, if immediate restoration has not been effected.
9. Well planned eye muscle surgery, aided by orthoptic exercises, is the best means of overcoming the residual diplopia and of restoring binocular single vision.

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TABLES AND CASE NOTES

In the subsequent tables and case notes the following abbreviations have been employed.

Muscles.

R.S.R. and L.S R.	... ...	Right and left superior rectus
R.E.R. and L.E.R.	... ...	Right and left external rectus
R. Int. R. and L Int. R.	...	Right and left internal rectus
R. Inf. R. and L. Inf. R.	...	Right and left inferior rectus
R.S.O. and L. S. O.	... ...	Right and left superior oblique
R. Inf. O. and L. Inf. O.	...	Right and left inferior oblique

R/L and L/R indicate right and left hyperphoria respectively

Maddox rod measurements are given in prism dioptres.

Synoptophore measurements:—

Lateral deviation in degrees.

Vertical deviation in prism dioptres.

F.R. and F.L.=fixing right and left eye, respectively.

Cyclophoria is measured in degrees.

TABLE I. *The treatment of traumatic diplopia by surgical adjustment of extra-ocular muscles, showing the Maddox rod readings at 6 metres before and after operation.*

Case No. Duty Age	Muscles affected and cause	Muscles adjusted	Maddox rod		Remarks
			Before	After	
1 W/Op Air Gun 22	R. Inf. R. & R.S.O. Aircraft crash	1. L.S.O. (2) R.S.R.	R/L 8△–10△	R/L 0△–3△	Residual diplopia only on extreme dextro-elevation. For further plastic repair of face.
2 Pilot 21	L.S.R. & L.E.R. Aircraft crash	R. Inf. O.	R/L 10△ Eso. 4△	R/L 2△	Fracture of orbital floor, revealed only by stereo X-ray. For further plastic repair of face.
8 Pilot 27	L.S.R. Aircraft crash	R. Inf. O.	R/L 4△	R/L 2△	Diplopia on laevo-elevation before operation. None after. Resumed flying.
10 Armourer 35	R. Inf. R. Contracture of right superior rectus, following operation for detached retina.	(1) R.S.R. (2) L. Inf. R.	R/L 3△–12△ Eso. 9△	Ortho.	Diplopia only on extreme dextro-elevation, and depression after operation. Return to duty.
12 Gunner 22	R.S.O. Direct injury to eye, with detachment of retina.	L. Inf. R.	R/L 3△–4△	Ortho.	Residual diplopia only on extreme laevo depression. Returned to duty.
13 Observer	R.S.R. Direct eye injury with laceration of left lower lid and adhesion round L.I.O.	L. Inf. O.	L/R 2△	L/R 1△	Cyclophoria and diplopia on dextro-elevation before operation. None after. Returned to flying duty.
14 Aircraftsman 33	R. Inf. R. & R.S.O. Piece of wood penetrated right orbit.	R.S.R. & R. Inf. O.	R/L 15△	R/L ½–3△	No diplopia $\bar{s}$ glasses after operation. Prisms worn previously. Returned to duty.

TABLE I—*continued*

Case No. Duty Age	Muscles affected and cause	Muscles adjusted	Maddox Rod		Remarks
			Before	After	
15 Pilot 22	R.S.O. Aircraft crash. Injury of frontal bone over right trochlea.	(1) Trochlea freed. (No benefit.) (2) L. Inf. R.	R/L 4△–6△	R/L 2△–3△	Diplopia caused by deep scarring over trochlea, from crash injury. Diplopia cured by second operation. Repatriated to Australia.
16 Fitter Eng. 32	L.S.R. Result of an obliterative operation on right frontal sinus two years ago.	R. Inf. O.	R/L 8△ Exo. 3△	R/L 2△ Eso. 2△	Diplopia caused by operation on Rt. frontal sinus. Diplopia cured by Op. on R. Inf. O. Returned to duty.
18 Pilot under- train 22	R.S.O. Aircraft crash. Compound fracture of the right frontal bone.	R. Inf. O.	R/L 12△–15△	R/L 4△	Diplopia after operation for cerebral abscess, following compound fracture of frontal bone. Diplopia cured by R.Inf. O. adjustment. To ground duty.
19 Pilot 23	L.S.R. Air accident.	R. Inf. O.	R/L 1△ Eso. 3△	Ortho.	Diplopia on laevo-elevation before operation. None after. Returned to flying.
20 Service Police 25	R.S O. Bullet wound.	L. Inf. R.	R/L 3△–4△	R/L 1△	Shot through right ethmoid and frontal sinus, resulting in diplopia on laevo-version. Symptomless after operation. Returned to duty.
24 Marine	R.S.O. Battle injury.	R. Inf. O.	R/L 14△–18△	R/L 4△	No diplopia. Returned to duty.
25 Soldier	R.S.R. Boxing Match.	L. Inf. R.	R/L 16△	R/L 2△-4△	Previously told nothing could be done. Now very pleased with eyes. Returned to duty.
29 Soldier	R. Inf. O. & R.S.R. Bicycle accident	L. Inf. O.	L/R 2△	L/R 1△	Diplopia on elevation before operation. No ocular symptoms after. Returned to duty.
30 Flight Eng. 23	Bilateral paresis external recti. Aircraft crash.	(1) R. Int. R. (2) L. Inf. O.	Eso. > 30△ L/R 5△	Eso. 8△ L/R 2△	Result of operation good. Resumed flying.

TABLE I—*continued*

Case No. Duty Age	Muscles affected and cause	Muscles adjusted	Maddox Rod		Remarks
			Before	After	
31 Pilot 22	L. Inf. O. & L.S.R. Aircraft crash.	(1) R.S.R. 3 snip (2) R.S.R. Recession 2 mm.	R/L 2△–3△	Ortho.	Diplopia on dextro-elevation before operation. Result of operation good. Resumed flying.
32 Aircraftsman 38	R.S.O. Bicycle accident Fracture of skull	R. Inf. O. for the excyclophoria, rather than the hyperphoria.	R/L 1△ Excyclo. 9°	R/L 1△ Excyclo. 4°	Improved after operation. For encephalography.
33 Army Officer	R.S.O. Car accident.	R. Inf. O.	R/L 12△ Eso. 6△	R/L 3△ Eso. 2△	Residual diplopia only on extreme laevo-depression. No further operation desired. Invalided.
34 Inst. Rep. 29	L.S.O. Bicycle accident	(1) R. Inf. R. (2) L. Inf. O. (3) R. Inf. R.	L/R 12△–14△ Exo. 3△ Excyclo. 10°	R/L 1△–3△ Eso. 4△ No excyc.	Returned to work.
35 Teleprinter 19	3rd nerve palsy of right elevators. Bicycle accident, cranio-cerebral injury	L.S.R. & L. Inf. O.	Eso. 9△ L/R 5△	Eso. 5△	Diplopia persisted L/R on depression. R/L on elevation. Invalided.
39 Soldier 36	L.S.R. Knocked out in a fight.	R. Inf. O.	R/L 18△ Eso. 6△	R/L 2△ Eso. 4△	Residual diplopia only on extreme laevo-elevation. No symptoms. Return to duty.
40 Balloon Op. 24	L.S.R. Air raid casualty	R. Inf. O.	R/L 3½△	R/L ½△	To rehabilitation unit.
41 Pilot 22	L.S.R. Air crash. Unconscious 4 days.	R. Inf. O.	R/L 2△–5△ Eso. 2△ Excyclo. 4°–7°	L/R 1△ Eso. 2△ No cyclo.	Satisfactory results. Resumed flying.
44 Flight Mech. 34	L. Ext. R. Knocked against wall by 500 lb. bomb.	(1) R. Int. R. (2) L. Int. R. (3) R. Int. R.	Eso.— 27△–30△ R/L 1△	Eso.— 11△–14△	Operation for diplopia on laevo-version. Binoc. range increased to 15° R. to L. Returned to duty.
46 Bombadier	Bilateral Ext.R. Bilateral Sup.O Motor cycle accident.	L. Inf. R.	Eso. 6△ R/L 1△–2△	Ortho.	Operation for diplopia on depression, particularly to left; Residual diplopia only on extreme depression after operation. To duty.

TABLE I—*continued*

Case No. Duty Age	Muscles affected and cause	Muscles adjusted	Maddox Rod		Remarks
			Before	After	
47 Pilot 30	R.S.R. Air crash. Fracture of both malar bones.	L.S.R.	Eso. 6△ L/R 1½△	Eso. 3△ L/R ½△	Diplopia on version following a/c crash resulting in mid third fracture of face. Improved after operation. Repatriated.
48 Soldier	R.S.O. Battle casualty.	(1) L. Inf. R. (2) R. Inf. O.	R/L 6△-9△ Eso. 3△	Ortho.	Returned to Unit.
49 Flight Eng. u/t. 24	L.S.R. Head injury at ice hockey.	(1) R. Inf. O. (2) L. Inf. R. (3) L. Inf. O.	R/L 8△	Ortho.	Ocularly fit flying after operation, but unfit on account of head injuries.
50 Pilot 34	L. Sup. R. Air crash.	R. Inf. O.	Excyclo. 4° R/L 1△	Eso. 3△ No cyclo.	Operation for cyclophoria. Resumed flying after operation.
52 Pilot 22	L.S.R. & L. Inf. O. Aircraft crash. Fracture of left maxilla.	R.S.R. & R. Inf. O.	R/L 10△-16△ Incyclo. 10°	Ortho.	Operation for cyclophoria on dextro-version and diplopia above eye level, Resumed flying after operation.
53 Pilot 23	L.S.O. Aircraft crash.	R. Inf. R. & L. Inf. O.	L/R 35△ Eso. 7△ Excyc. 6°	L/R 3△-5△ Eso. 5△	Residual diplopia on dextro-depression only. Discharged P.O.W.
54 Soldier	R.E.R. Complete paralysis. Battle casualty.	(1) R. Int. R. (2) L. Int. R. (3) "O'Connor's" muscle transplantation from right superior & inferior recti.	No measurements possible. approx. +	Angle 40°	Movements increased to 15° to left. Eso. 5△ ahead. No diplopia. Invalided.

TABLE II—*10 Examples of Group I (Diplopia caused by derangement of the normal bony architecture around the eye)*

TABLE II—*10 Examples of Group I (Diplopia caused by derangement of the normal bony architecture around the eye)*

No.	Age	Occupation	Injury	Diagnosis	Treatment	Synoptophore angle. At centre, and to side where greatest deviation occurred		Maddox rod		Result and Disposal
						Before treatment	After	Before	After	
1*	22	Air Gunner	Aircraft crash. Compound fracture L. frontal bone	Displacement of trochlea of L. Sup. oblique with overaction of L. depressors	(1) Lengthening of L.S.O. (2) Recession of R. Sup. rectus	Centre 0° R/L5△—7△ to Right R/L7△—8△	0° R/L½△ 0° R/L½△	Exo. 1△ R/L 8△—10△	FR. R/L 0△—1△ FL R/L 2△—3△	No diplopia with all normal eye movements. For further plastic operation.
2*	21	Pilot	Aircraft crash. Burns-fracture of both malar bones and floor of L. orbit	Obstruction of L. naso-lacrymal duct and paresis of L. sup. rectus	(1) Dacryocysto-rhinostomy (2) Tenectomy of rt. inf. oblique	Centre +1° R/L7△—8△ to Left 3° R/L16△—18△ Excyclo. 4°△	0° R/L1△ 0° R/L4△—5△ No excyclophoria	R/L 10△	R/L 2△	do.
3	24	Pilot	Aircraft crash. Facial injuries	Fracture of L. malar, Paresis of L. sup. rect. L. sup. oblique	(1) Elevation of L. malar (2) Orthoptic exercises	No immediate measurements possible	At centre and to sides-orthophoric		— to L/R ½△	No diplopia. Resumed flying. At last check had flown 100 hrs. since discharge.
4	26	Turner	Knocked out in a fight	Fracture of L. maxilla Comminution of floor of orbit. Limitation of elevation. L.E.	(1) Elevation of zygoma (2) Packing of L. antrum (3) Bone platform to floor of L. orbit	No immediate measurements possible	Centre +1°R/L 1△—2△ Fixing R. & L. to Left R/L 3△—4△ Fixing R. & L.		L/R 1△—2△ Fixing R. & L.	Returned to his precision work—orthophoric ahead but some vertical diplopia up and down.
5	26	Wireless Op.	Machine gun bullet through nose to L. temple	Paralysis of L. depressors. Fractured nasal and lacrymal bones and floor of L. orbit ruptured. Choroid.	(1) Dacryocysto-rhinostomy (2) Bone graft and chips to raise floor of L. orbit	Left eye 7 mm. below right	Some over-correction	No binocular vision		Cosmetic result—the retinal damage and hypertropia caused suppression of L. vision.

TABLE II—*continued*

No.	Age	Occupation	Injury	Diagnosis	Treatment	Synoptophore angle. At centre, and to side where greatest deviation occurred		Maddox rod		Result and Disposal
						Before treatment	After	Before	After	
6	26	Aircraft man	Struck on face by 250 lb. bomb	Unreduced fracture of L. malar bone, paresis of L. Inf. R.						Fracture of L malar bone was missed. When admitted to hospital, diplopia not very troublesome owing to partial atrophy of L. optic N.
7	30	Pilot	Shot down. 3 months ago crash landed. Hit face on gunsight	Old fracture of L. malar. Defective elevation of left eye	Orthoptic exercises	Centre 0° R/L½△ To L &R.—1° R/L½△ Adduction +10° only	Same but adduction power increased to + 35°	R/L 1△—fixing R. R/L 2△—fixing L.	same as before	Much improved but not cured by orthoptic exercises. Can now read for ¾ hour. Returned to non-operational flying.
8	27	Pilot	Aircraft crash in desert	Fracture of R. frontal bone. L. maxilla and nasal bones. Paresis of L, sup. rectus.	Tenectomy of right inferior oblique	Centre 0° R/L6△ to Left 0° R/L10△	0° R/L 2△—3△ in all positions	R/L 6△—7△ Exo. 2△	R/L 2△—3△ Exo. 1△	No diplopia. Resumed flying (non-operational).
18*	22	Pilot u/t	Aircraft crash	Compound fracture of R. frontal bone	Tenectomy of right inferior oblique			R/L 12△—15△	R/L 4△	Not a fully trained pilot, returned to ground duties. No diplopia.
52*	22	Pilot	Aircraft crash	Fracture of left maxilla with paresis of L. elevators	(1) Wiring of front. to malar suture (2) Adjustment of right elevators	Centre R/L9△—11△ to Right —5°R/L15△	Centre R/L 1·5△ to Right −5° R/L 5△	R/L 10△—16△ —F.R. R/L 5△—F.L.	Orthophoric	No diplopia. Resumed flying (non-operation).

* Also included in Table I under muscle adjustments.

CASE No. 1.

HISTORY.

E. G. C., aged 22 years. Wireless operator/air gunner. Aircraft crash on North-west frontier of India on April 17, 1943. He sustained a compound fracture of the left frontal bone. Double vision since the accident which improved to some extent but has remained stationary for six months. First seen in hospital in August, 1944, when he had a large bony protuberance over the left eye owing to the forward dislocation of the fractured frontal bone as shown in the X-ray picture. There was over-action of the left superior oblique and a relative paresis of the right inferior rectus. He was transferred to the Plastic Unit for the remodelling of the supra-orbital ridge.

PRE-OPERATIVE EXAMINATION. January 1, 1945.

Vision :—R. 6/5. L. 6/5.

Movements :—Defective depression of the right eye and gross overaction of the left.

Diplopia :—Vertical, with maximum separation of images on dextro-depression, lower image belonging to the right eye.

Maddox rod :—Fixing right—R/L 8 pd. Exophoria 1 pd.
Fixing left—R/L 10 pd. Exophoria 1 pd.

Synoptophore :—S.P. angle—fixing right—centre ... 0° R/L 4–6 pd.
to right ... R/L 7–8 pd.
to left ... R/L 4–6 pd.
fixing left—centre ... 0° R/L 5–7 pd.
to right ... R/L 7–8 pd.
to left ... R/L 5–7 pd.

Left incyclophoria 3°
Fusion 0°. R/L 4△ : can infraduct to 0
Adduction to + 30°
Abduction to − 2°

Hess chart 1.—Right eye—paresis of right inferior rectus and superior oblique.
Left eye—overaction of depressor muscles.

Diagnosis :—Displacement of trochlea of left superior oblique.

OPERATION. January 26, 1945.

Slide lengthening of tendon of left superior oblique between trochlea and the globe.

POST-OPERATIVE MEASUREMENTS. February 1, 1945.

Maddox rod :—R/L 8 pd. Exophoria 2 pd. Fixing right and left.

Diplopia :—Now corresponds, mainly, to paresis of left inferior oblique ; slightly, to paresis of right inferior rectus. Hess chart 2.

OPERATION. February 7, 1945.

Recession of right superior rectus 3 mm.

POST-OPERATIVE MEASUREMENTS. February 16, 1945.

Maddox rod :—Fixing right ... R/L 0△–1△.
Fixing left ... R/L 2△–3△.

Maddox wing :—Exophoria 2°–4°. No hyperphoria.

Diplopia :—Only on looking well up to the right.

Synoptophore :—S.P. angle—centre ... 0° R/L ½ pd.
to right ... 3° R/L ½ pd.
to left ... 0° R/L ½ pd.

Fusion − 0°. No hyperphoria.
Adduction + 50°.
Abduction to − 5°.
Stereoscopic vision—full.

Hess chart 3 :—Slight deviation on extreme dextro-elevation.

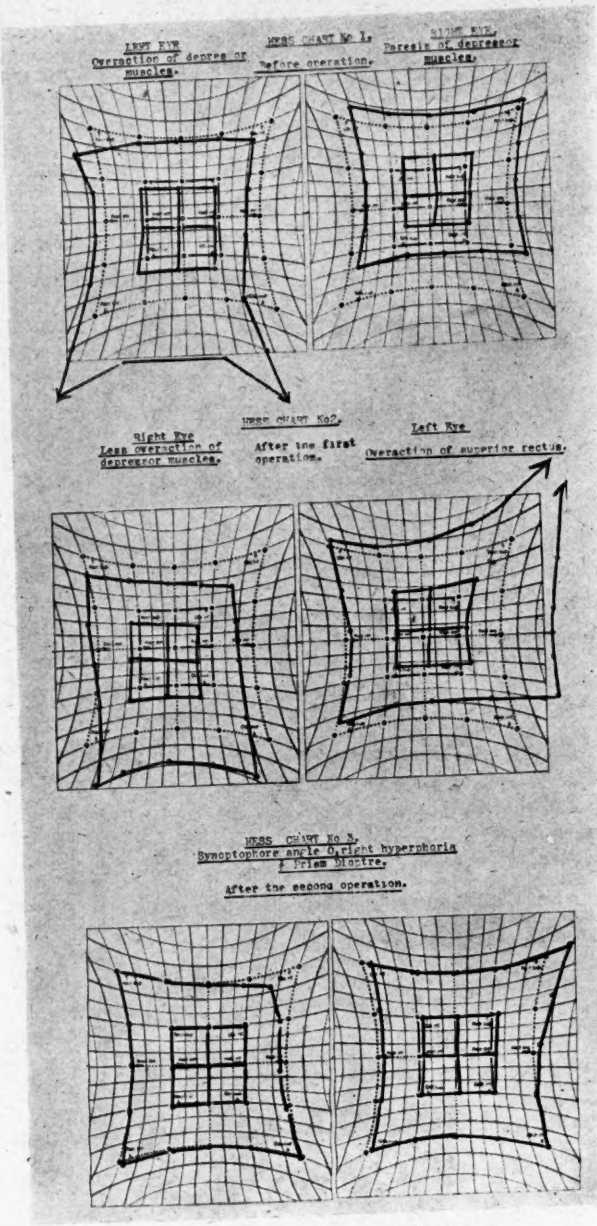
DISPOSAL.

To return to the plastic centre after convalescence, for further treatment. No ocular symptoms.

* Also included in Table I under muscle adjustments.

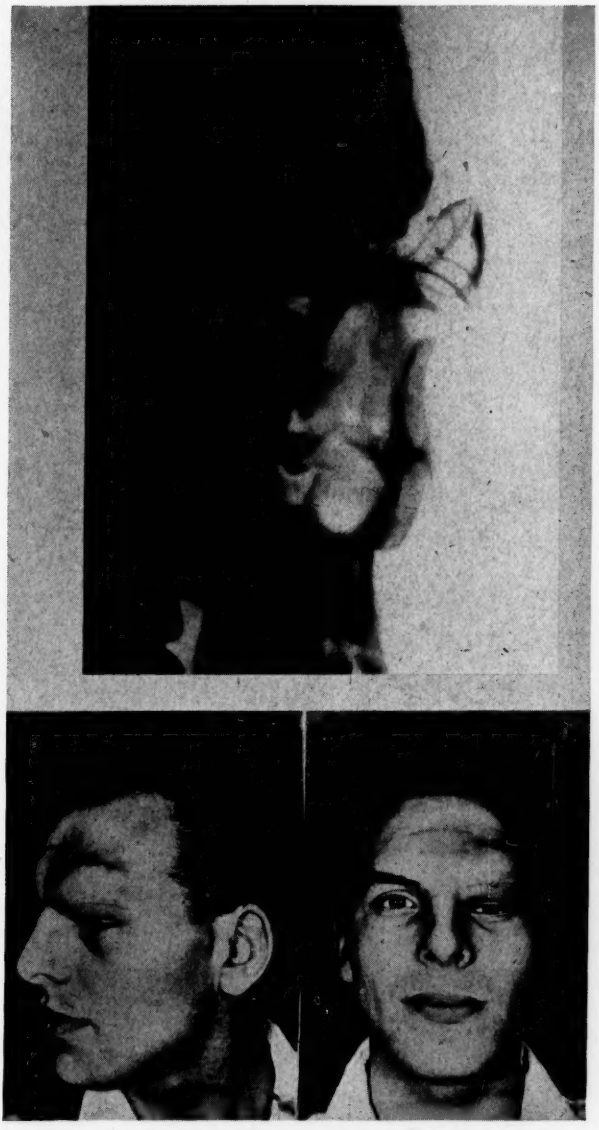
Right elevators

CASE 1


LEFT EYE
Overaction of depres. or muscles.
HESS CHART No 1.
Before operation.
RIGHT EYE.
Paresis of depressor muscles.
Right Eye
Less overaction of depressor muscles.
HESS CHART No2.
After the first operation.
Left Eye
Overaction of superior rectus.
HESS CHART No 3.
Synoptophore angle O right hyperphoria
1 Prism Dioptre.
After the second operation.

CASE 1

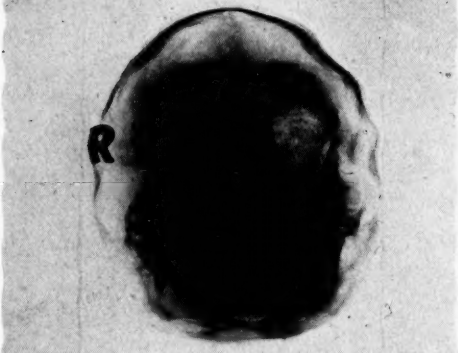
Compound fracture of the left frontal bone; forward dislocation of the lower fragment.



Showing the supra-orbital margin, after it had been re-shaped by a plastic operation, and the displaced position of the left eye, before the operations on the extra-ocular muscles.

Case No 2.

No1 X RAY PHOTOGRAPH IN THE "A.P." POSITION.
NO FRACTURE SEEN.



No.2. X RAY PHOTOGRAPH IN THE VERTICO-MENTAL POSITION
Fracture of left orbital floor. Separation of fronto-malar suture. Maxillary antrum is obscured, presumably by blood clot.

EXTENSIVE OEDEMA, INVOLVING MOST OF THE FACE, MASKING
MOST LANDMARKS. (AIR CRASH.)

CASE 5.

FRACTURE OF LEFT MALAR AND MAXILLA.

FLOOR OF THE LEFT ORBIT REBUILT BY A BONE GRAFT
FROM THE ILIAC CREST

Before the bone inlay

On leaving hospital .

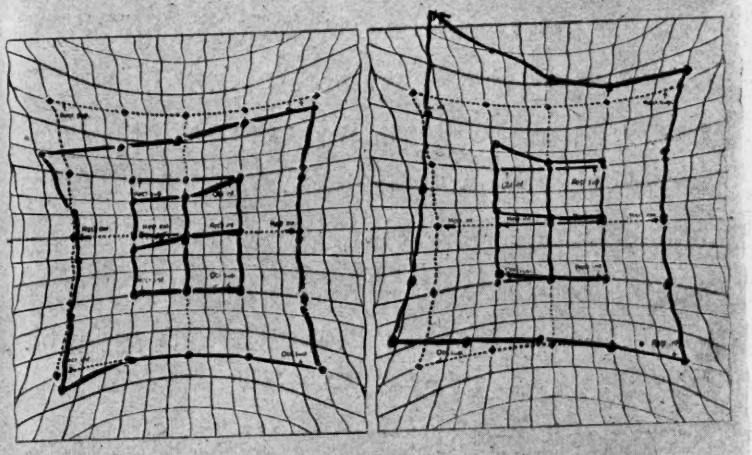
CASE 13.

CASE 2.

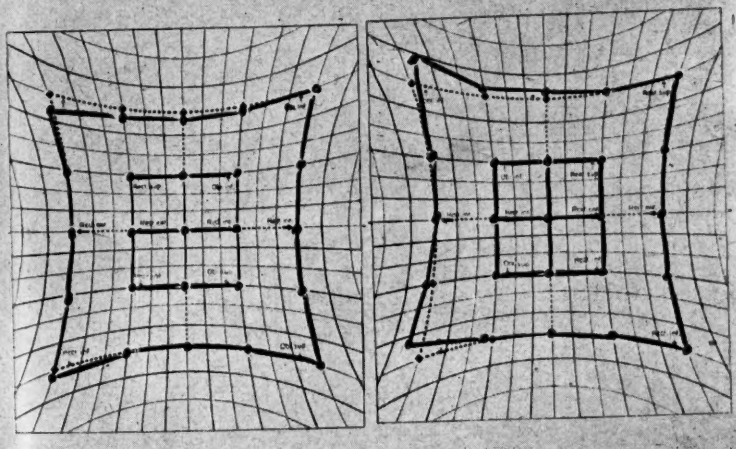
PRE-OPERATIVE HESS CHART.

Left Eye.
Paresis of superior rectus

Right Eye.
Overaction of inferior oblique.



POST-OPERATIVE HESS CHART.



Practically Normal

CASE No. 2.

HISTORY.

J. C., aged 21 years. Pilot. On August 13, 1944, aircraft, of which he was pilot, crashed and burst into flames. Admitted to Burns Unit 1½ hrs. later with extensive burns and fractures. Injuries included depressed fracture of right malar, and a comminuted fracture of left external malleolus. Depression of left orbital floor shown later (v.i.). On September 28, 1944, burns well healed. Leg in plaster below the knee. Referred to ophthalmologist on account of a head tilt and diplopia.

PRE-OPERATIVE EXAMINATION. October 13, 1944.

Right malar fracture with obstruction of the right naso-lacrymal duct. Holds head over to the left.

Vision :—R 6/6. L. 6/6.

Movements :—Limited elevation of left eye, looking to left, with overshoot of right eye. Slight limitation of left external rectus.

Diplopia :—Vertical to left; lower image belonging to the right eye, increasing on elevation.

Maddox rod :—Esophoria 3–5 pd. R/L 10 pd.

Synoptophore :—S.P. angle—centre ... + 1° R/L 7–8 pd.
to right ... + 1° R/L 2–4 pd.
to left ... − 3° R/L 16–18 pd.
Fixing left eye slightly more than fixing right.
Fusion—0°. R/L 7 pd. Excyclophoria 4°.

Hess chart :—Right eye—overaction of right inferior oblique.
Left eye—paresis of left superior rectus.

Diagnosis :—Paresis of left superior rectus, left external rectus.

OPERATION. November 6, 1944.

Myectomy of the right inferior oblique, at the same time as a right dacryocystorhinostomy.

POST-OPERATIVE MEASUREMENTS.

Maddox rod :—R/L 2 pd.

Synoptophore :—S.P. angle—0° R/L 1 pd. 25° to left—R/L 4–5 pd.
Fusion—0°. No hyperphoria.
Adduction to + 30°.

Movements :—Much improved, see Hess chart No. 2.

DISPOSAL.

To leave. To be re-admitted to the Plastic Unit for further repair.

COMMENT. The clinical features of this case were at first masked by the extensive swelling caused by the burns. An X-ray photograph taken in the antero-posterior position revealed no fracture of the facial bones (picture 1). Stereoscopic pictures taken later in the vertico mental position, showed depression of the left orbital floor and separation of the fronto-malar suture (picture 2). It is of significance, therefore, that these fractures can be, and often are, missed unless stereoscopic X-ray photographs are taken in the vertico-mental position of the head.

CASE No. 11.

HISTORY.

C. C., aged 28 years. Instrument repairer II. On March 25, 1944, he stumbled over a tree in the blackout and a branch penetrated the lower lid of the right eye, passing backwards between the orbit and the globe. He was taken to a military hospital, where he was found to be suffering from ptosis of the right upper lid, proptosis due to severe retrobulbar haemorrhage, and absent eye movements. Some slow recovery took place and the vision improved to Right 6/9 with − 0.50 cyl 180° = 6/6. Left vision 6/6.

He was transferred to another military hospital where the following report was made :—

"As a result of a perforating wound of the orbit, this man appears to have damaged the right third and sixth nerves. I recommend a shade for the right eye and prolonged convalescence."

After a further month he was recommended for invaliding on account of intractable diplopia :—

"The lesion may well be permanent, and I think he should be discharged as unfit for further service."

CASE 11.

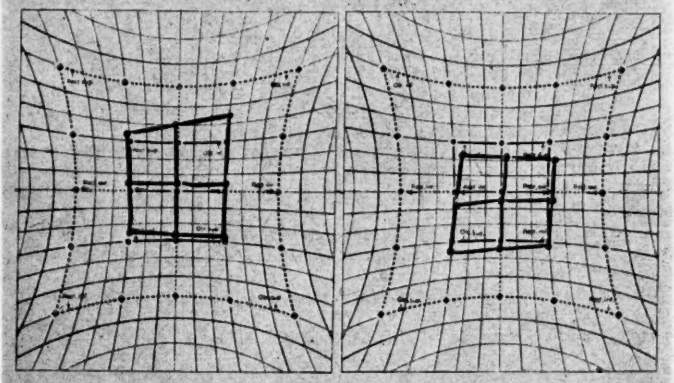
HESS CHART .No.1.

26-May 1944.

BEFORE TREATMENT.

Left Eye.
Overaction of the elevator muscles, particularly the inferior oblique.

Right Eye.
Paresis of the elevator muscles.

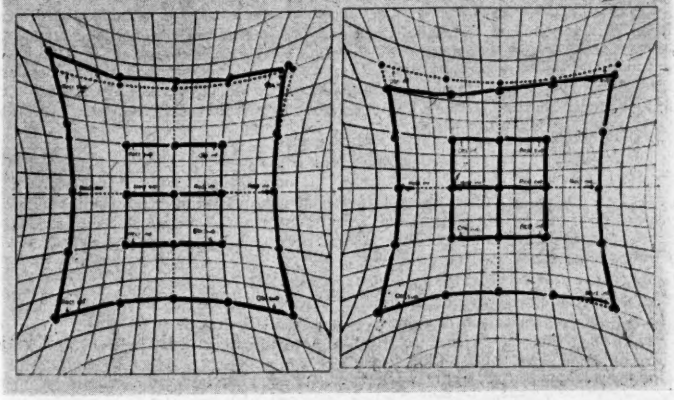


HESS CHART No.2.
27th June 1944.

AFTER TREATMENT.

Left Eye
Slight overaction of the superior rectus, (outer square only .)

Right Eye
Very slight paresis of the inferior oblique (outer square only.)



As a result of this pessimistic prognosis, this man was admitted to hospital on May 26, 1944, in a morbid and dejected condition to be, as he thought, invalided from the service. He was complaining of diplopia, mainly vertical in type, which had persisted unaltered since the time of his accident. He had suffered from no previous ocular abnormality and had never worn glasses.

EXAMINATION.

Vision :—R. 6/36—with no correction and much persuasion = 6/9.
L. 6/18—with + 0.50 sph./—1.0 cyl. at 180° = 6/9.
Movements :—Full.
Diplopia :—Vertical, maximum separation of images on laevo-elevation, the upper image belonging to the right eye.
Maddox rod :—Fixing right—L/R 3·5 pd. Exophoria 2 pd.
Fixing left—L/R 3·5 pd. Exophoria 1 pd.
Synoptophore :—S.P. angle—+1°. L/R 5 pd. 20° to right—L/R 7 pd.
Fusion—0° L/R 4 pd.
Infraduction 2 pd.
Adduction to 20° with effort.
Diagnosis :—Primary paresis of the right inferior oblique.

The notes of the case read, " this man is at present in a somewhat unco-operative state, he requires encouragement on the lines that he is going to get single vision, but must do his part to assist."

TREATMENT.

Orthoptic exercises.

At the end of the exercises he was sent out on a week's sick leave with the assurance that he would fully recover.

ON READMISSION. June 20, 1944.

Maddox rod :—L/R 1 pd. only.
Synoptophore :—S.P. angle—0°. L/R 2 pd.
Fusion—0°. No hyperphoria.

DISPOSAL.

Returned to duty.

Hess chart 1 :—Before treatment. R.E. Paresis of the elevator muscles.
L.E. Overaction of the elevators, particularly the inferior oblique.
Hess chart 2 :—After treatment. R.E. Very slight paresis of the inferior oblique.
L.E. Slight overaction of the superior rectus.

COMMENT. This record is given in full to illustrate the value of orthoptic exercises in the treatment of these cases.

Two months after an injury, this patient was complaining of a diplopia which had remained unaltered since the time of his accident. After a two weeks' course of orthoptic exercises his actual physical, as well as mental, outlook had completely altered, and the angle on the synoptophore had been reduced from L/R 8 to L/R 2.

It is not claimed that orthoptic exercises will cure a tropia, but they seem, as in this incidence, to light the path which leads to recovery, and supply the necessary stimulus to enable the patient to regrasp and to hold with increased adduction strength, binocular single vision.

CASE No. 13.

HISTORY.

G. Y. S. Observer. On October 13, 1942, lacerated his left lower lid when he slipped and struck his head on a wire fence. The wound on his cheek turned septic and he says was followed by dizziness and fever. Now complaining of headaches and eye-strain after close work.

PRE-OPERATIVE EXAMINATION. February 18, 1944.

Vision :—R 6/6. L. 6/6.
Movements :—Limitation of right eye in dextro-elevation.
Diplopia :—Vertical, with maximum separation of images in dextro-elevation, the upper image belonging to the right eye.
Maddox rod :—Fixing right and left ... 2 pd. L/R.
Fixing right ... 2 pd.
Fixing left ... ... 1 pd.

Synoptophore :—S.P. angle— −1°. L/R 1 pd., increasing to L/R 2 pd. 25° to right, with excyclophoria.
Fusion −0°.
Adduction +10°.
Abduction — 5°.
Hess chart :—Right eye—paresis of right superior rectus.
Left eye—overaction of left inferior oblique.
Diagnosis :—Paresis of right superior rectus.

OPERATION. March 6, 1944.

Left inferior oblique tenotomy.

POST-OPERATIVE MEASUREMENTS.
Maddox rod :—L/R 2 pd.
Synoptophore :—S.P. angle—0°. L/R 2 pd. 20° to right—L/R 2½ pd.
Fusion −0°.
Adduction +20°, the L/R which increased with further adduction to L/R 8–9 pd.

OPERATION. April 4, 1944.

Division of adhesions round inferior oblique of left eye.

POST-OPERATIVE MEASUREMENTS. April 10, 1944.
Movements :—Full. No diplopia.
Maddox rod :—Esophoria 1 pd. L/R 1 pd.
Synoptophore :—S.P. angle—0°. L/R 1 △ in all positions.
Fusion—0°. Supraduction to R/L 7 pd.
Adduction +35°.
Abduction — 5°.
Hess chart :—No muscle imbalance on inner or outer chart.

DISPOSAL.

To Medical Board. Returned to flying duties.

CASE No. 15.

HISTORY.

S. W. B., aged 25 years. Pilot. Returning from operational trip in a Typhoon (August 25, 1943) he was caught in the slip stream of the preceding machine, which, coming in a little high, elected to go round the airfield again, the port wing stalled and the Typhoon cartwheeled. Concussed for 16 hours with islets. Discharged from Army hospitals September 15, 1943, and admitted to an R.A.F. hospital October 7, 1943, suffering from (1) deep scarring of right upper lid at site of laceration, and (2) diplopia ; this had been noticed since the time of the accident.

Now finds diplopia very troublesome when reading or walking downstairs.

PRE-OPERATIVE EXAMINATION.
Vision :—Right—6/9 with −0·75 cyl. at 180°—6/6.
Left—6/5.
Movements :—Limitation of depression of right eye, especially on laevo-depression. Upper lid remains retracted at the inner angle on looking down.
Diplopia :—On laevo-version increasing on depression, the lower image belonging to right eye.
Maddox rod :—Exophoria 1 pd. R/L 2 pd.
Synoptophore :—S.P. angle −3°. R/L 1 pd., increasing to 2½ pd. to left.
Adduction +8°.
Abduction −5°.
Hess chart 1 (October 13, 1943) :—Right eye—shows paresis of right superior oblique.
Left eye—shows overaction of left inferior rectus.
Diagnosis :—Paresis of right superior oblique, due to injury and scarring round the trochlea.

OPERATION. November 18, 1943.

Scar on upper lid excised and an attempt made to free the trochlea. One week's orthoptic treatment followed.

POST-OPERATIVE EXAMINATION.
Diplopia :—Not improved.

Maddox rod :—Exophoria 2 pd. R/L 4 to 6 pd. (worse than before). Re-admitted December 31, 1943, for a skin graft to right upper lid.

EXAMINATION ON April 2, 1944.

Maddox rod :—Fixing right—R/L 6 pd. Esophoria 1 pd.
Fixing left—R/L 10 pd. Esophoria 2 pd.
Synoptophore :—Fixing right—R/L 8 pd., increasing to left.
Fixing left—R/L 5 pd., increasing to left.

June 30, 1944. Injured by a flying bomb in London. He sustained (1) rupture of tympanic membranes, (2) concussion, and (3) laceration of scalp. After recovering from these injuries he was re-admitted to hospital October 3, 1944.

PRE-OPERATIVE EXAMINATION. October 5, 1944.

Double vision has remained constant during the past five months, now fourteen months since his crash. Slight right enophthalmos.

Vision :—Right—6/5 with +0·25 sphere—6/5.
Left—6/5 with +0·25 sphere—6/5.
Movements :—Limitation of depression of right eye, especially to the left.
Diplopia :—Corresponds to paresis of right superior oblique muscle—as before.
Maddox rod :—Fixing right—R/L 4 pd., no lateral deviation.
Fixing left —R/L 6 pd., no lateral deviation.
Slight downward movement of head makes deviation R/L 12 pd.
Synoptophore :—S.P. angle—fixing right—centre ... 0° R/L 4 pd.
25° to right 0° R/L 2·5 pd.
25° to left ... 3° R/L 26 pd.
fixing left —centre ... 0° R/L 3½ pd.
25° to right R/L 2 pd.
25° to left ... 3° R/L 23 pd.
right excyclophoria 2°.
Fusion angle—0° R/L 4 pd., no infraduction.
Adduction to 25°.
Abduction to −4°.
Hess chart 2 :—Worse than before, with Inhibitional palsy L. S. Rect.
B.H.T.D. :—(P.D. 60) R/L 20 = (Bishop Harman Diaphragm Test).

OPERATION. October 23, 1944.

Recession of left inferior rectus 3 mm.

POST-OPERATIVE MEASUREMENTS. October 31, 1944.

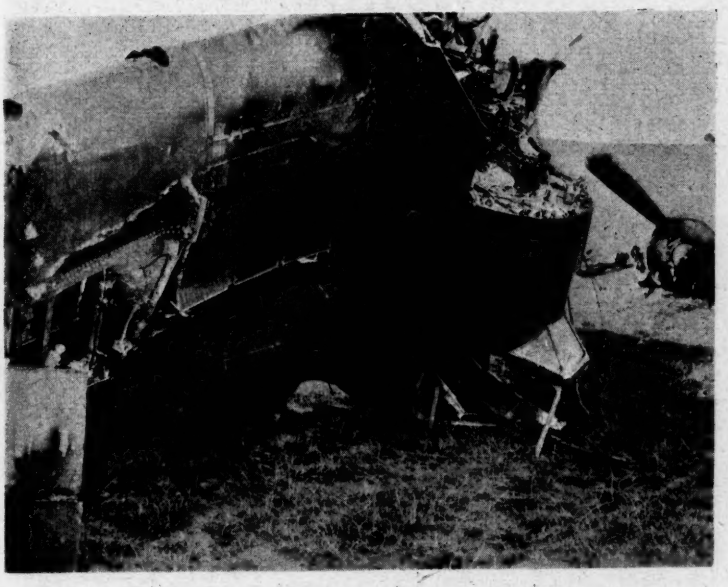
Maddox rod :—Fixing right—R/L 1 pd.
Fixing left —R/L 1 pd.
Maddox wing :—Orthophoric.
Synoptophore :—S.P. angle—centre ... −2° L/R 1 pd.
25° to right ... L/R 1·5 pd.
25° to left ... R/L 1·5 pd.
Fusion—0. No hyperphoria.
Adduction to +35°.
Abduction to −5°.
B.H.T.D. :—(P.D. 60) R/L at 4.
Maddox rod :—Increased to R/L 2–3 pd., after 14 days, but eyes remained comfortable and patient could read without difficulty.
Diplopia :—Experienced only at extreme of vision down to left and up to right.

MEASUREMENTS. November 16, 1944.

Maddox rod :—Exophoria 1 pd.—fixing right—R/L 3 pd.
fixing left —R/L 2 pd.
Diplopia :—R/L on laevo-depression.
Synoptophore :—S.P. angle—fixing right—centre ... 0° R/L 3–4 pd.
to left ... R/L 7 pd.
fixing left —centre ... 0° R/L 1–2 pd.
to left ... R/L 5 pd.
Fusion—0°, no hyperphoria to sides.
Adduction to +45°.
Abduction to −5°.
Hess chart 3 :—Very good.
Eyes very comfortable and can read without difficulty.

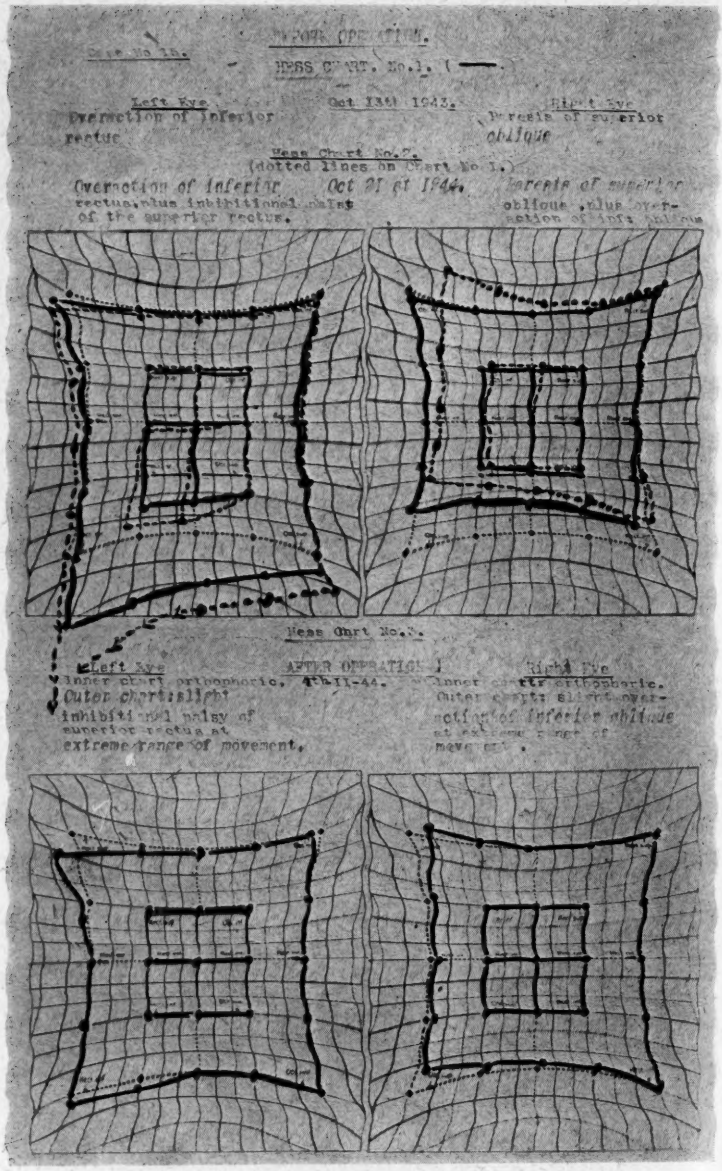
DISPOSAL.

To Medical Board. Repatriated to Australia.



CASE 15.

Extensive wreckage of Typhoon from which the pilot emerged with nothing worse than concussion and diplopia, from which he made a complete recovery.


Case No 15.
HESS CHART. No.1. (——.
Left Eye
Oct 13th 1943.
Right Eye
Overaction of inferior rectus
Paresis of superior oblique
Hess Chart No.2.
(dotted lines on Chart No 1.)
Overaction of inferior rectus, minimum inhibitional palsy of the superior rectus.
Oct 21 st 1944.
Paresis of superior oblique, plus overaction of left inferior
Hess Chart No.3.
Left Eye
AFTER OPERATION
Right Eye
Outer chart slight inhibitional palsy of superior rectus at extreme range of movement.
Outer chart slight overaction of inferior oblique at extreme range of movement.

CASE 18—*BEFORE OPERATION*

AFTER OPERATION

CASE No. 18.

HISTORY.

A. C. H., aged 22 years. Pilot—under training. Crashed in Canada in August 1942, when the navigator fainted and fell across the controls. He sustained a compound fracture of the frontal bone; this was followed by a cerebral abscess which was drained in Canada. He noticed diplopia after the operation. On returning to England, two operations were performed, for repair of his frontal bone.

PRE-OPERATIVE EXAMINATION. October 27, 1943.

Marked head tilt down and to the left.

Vision :—R 6/5. L. 6/5.

Movements :—Limitation of right eye on laevo-depression and laevo-version.

Diplopia :—Vertical. Maximum separation of images on laevo-depression, the lower image belonging to the right eye.

Maddox rod :—Fixing right—Exophoria 1 △. R/L 15 pd.
Fixing left —Exophoria 1 △. R/L 12 pd.

Synoptophore :—S.P. angle—fixing right—centre ... 0° R/L 8 pd.
20° to right ... R/L 4 pd.
20° to left ... R/L 15 pd.
fixing left —centre ... R/L 6 pd.
20° to right ... R/L 3 pd.
20° to left ... R/L 14 pd.

Fusion—0°. No hyperphoria straight ahead.
Adduction +25°.
Abduction −4°.

Hess chart :—Right eye—paresis of right superior oblique, secondary overaction of right inferior oblique.
Left eye—overaction of left inferior rectus.

Diagnosis :—Paresis of right superior oblique.

OPERATION. January 12, 1944.

Right inferior oblique myectomy.

POST-OPERATIVE MEASUREMENTS.

Maddox rod :—No horizontal deviation. R/L 4 pd.

Synoptophore :—S.P. angle—0° R/L 4 pd. increasing to R/L 5 pd. to left.
decreasing to R/L 3 pd. to right.

Fusion—0°.
Adduction +30°.
Abduction −5°.
Supra-duction L/R 4 pd.

DISPOSAL.

To ground duty.

CASE No. 30.

HISTORY.

J. R. D., aged 23 years. Flight engineer. Aircraft crashed and caught fire on June 7, 1944. He sustained burns to right arm, wrist, face and neck. Had a period of amnesia of ½ hour before, and 3 hours after the accident. Pilot was severely wounded, air gunner died. He complained of diplopia immediately he could concentrate after the accident. X-ray of skull showed no fracture. Thought to be hysterical.

PRE-OPERATIVE EXAMINATION. September 2, 1944.

Vision :—R. 6/6 with +0·75 sphere = 6/5.
L. 6/6 with +0·25/+0·50 cyl. at 85° = 6/5.

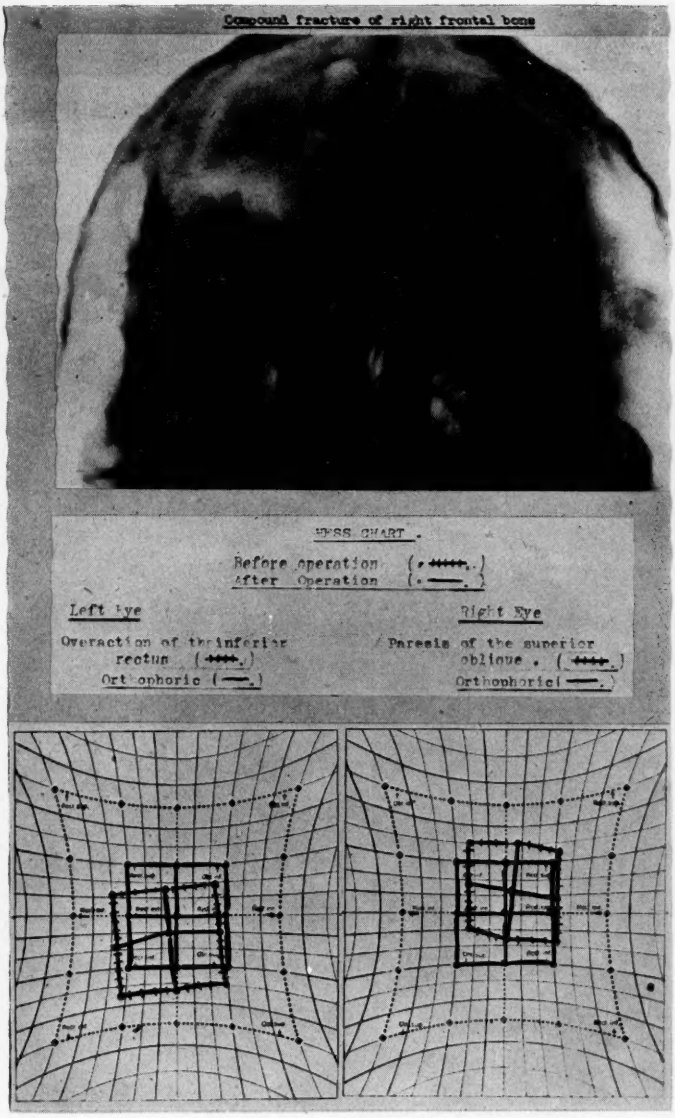
Movements :—Weakness of external recti and over elevation of left eye on dextro-version.

Diplopia :—Homonymous at all distances over 1 foot, with left hyperphoria increasing to right.

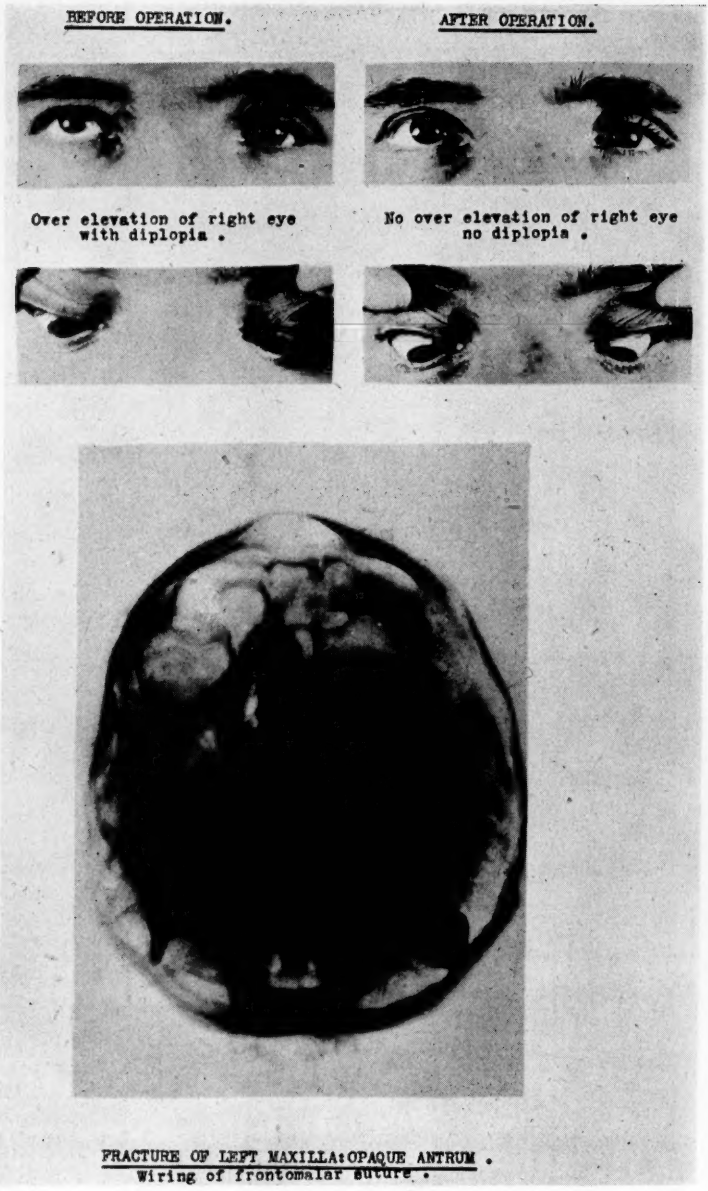
Maddox rod :—Esophoria greater than 30 pd. Left hyperphoria 5 pd.

Synoptophore :—S.P. angle—fixing right—centre ... +18°. L/R 6 pd.
to right ... L/R 10 pd.
to left ... L/R 1 pd.
fixing left —centre ... +15°. L/R 2 pd.
to right ... L/R 5 pd.
to left ... L/R 4 pd.

Case 18


Compound fracture of right frontal bone
HESS CHART.
Before operation (.+++++.)
After Operation (.——.)
Left Eye
Overaction of the inferior rectum (++++.)
Orthophoric (——.)
Right Eye
Paresis of the superior oblique . (++++.)
Orthophoric (——.)

CASE 52


BEFORE OPERATION.
AFTER OPERATION.
Over elevation of right eye with diplopia .
No over elevation of right eye no diplopia .
FRACTURE OF LEFT MAXILLA: OPAQUE ANTRUM .
Wiring of frontomalar suture .

Fusion +15°. L/R 3 pd.
Adduction to 28° with increase of left hyperphoria.
Abduction to +10°.

Hess chart :—Bilateral paresis of external recti—right more than left.

Diagnosis :—As Hess chart above.

September 26, 1944. Improvement with exercises. Now no diplopia for close objects at about 3 feet. Had 14 days leave.

Synoptophore (October 11, 1944) :—S.P. angle +8. L/R 4△–5△ straightening to + 2 pd.

Maddox rod (November 6, 1944) :—Still shows esophoria 10–25 pd.

OPERATION. November 8, 1944.

Recession of right internal rectus.

POST-OPERATIVE MEASUREMENTS. November 12, 1944.

Synoptophore :—Angle much the same as before.

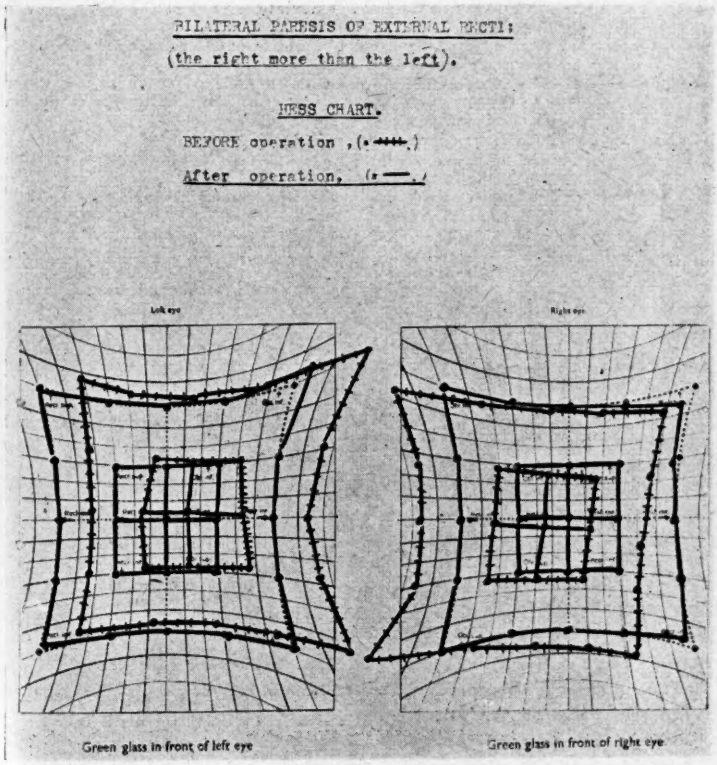
OPERATION. November 15, 1944.

Tenotomy of left inferior oblique.

POST-OPERATIVE MEASUREMENTS. November 21, 1944.

Maddox rod :—Esophoria 8△ L/R 2 pd.

CASE 30


BILATERAL PARESIS OF EXTERNAL RECTI:
(the right more than the left).
HESS CHART.
BEFORE operation ,(
After operation, (
Left eye
Right eye
Green glass in front of left eye
Green glass in front of right eye

Synopotophore :—S.P. angle +3°–4° L/R 1 pd. 25° to right—L/R 3 pd.
Fusion—0°. No hyperphoria. Holds to sides.
Adduction to +25°.
Abduction to −6°.
Hess chart :—Very good indeed.

DISPOSAL.

To Central Medical Board. Passed fit for flying duties.

CASE No. 34.

HISTORY.

R. W., aged 29 years. Instrument repairer. Accident on July 25, 1942. Thrown over handlebars of bicycle. Noticed double vision on recovering consciousness. It is reported that there was definite evidence of severe damage to the central nervous system—weakness of limbs in all movements to the right. Diplopia was at first present in all directions, now has single binocular vision on looking about 20 to the left, otherwise the vertical diplopia is still present, and increases on looking to the right. Says he has learnt to put up with it fairly well, as he concentrates on the higher image. Has very marked head position ; head down and chin towards the right shoulder.

PRE-OPERATIVE EXAMINATION. November 22, 1942.

Vision :—R. 6/6. L. 6/6.
Movements :—On dextro-version the left eye deviates upwards.
On dextro-depression—defective depression of left eye.
On dextro-elevation—defective elevation of right eye with over-elevation of left eye.
Diplopia :—Vertical. Maximum separation down and to the right, the lower image belongs to the left eye. There is also tilting of the image seen by the left eye inwards (excyclo).
Maddox rod :—Fixing right—Exophoria 3 pd. L/R 12 pd.
Fixing left —No lateral deviation. L/R 14 pd. very variable and some excyclophoria.
Synoptophore :—S.P. angle—centre ... 1° L/R 15 pd., excyclophoria 10°–12°.
20 to right 1° L/R 10 pd. excyclophoria 10°.
20 to left 1° L/R 2 pd. excyclophoria 2°.
Fusion —centre ... O° L/R 10 pd. excyclophoria 10°, very little infraduction.
Side movements impossible on account of incomitance.
Adduction to +5°.
Abduction to −2°.
L. hyperphoria very variable throughout tests.
Hess chart :—Shows paresis of the left superior oblique.
Shows paresis of the right superior rectus.
Shows overaction of right inferior oblique.
Diagnosis :—Paresis of the left superior oblique. Secondary paresis of the right superior rectus.

OPERATION. November 25, 1942.

Retroplacement of the right inferior rectus 2–3 mm.

POST-OPERATIVE MEASUREMENTS.

Maddox rod :—Fixing right—Esophoria 1△ L/R. 6 pd.
Fixing left —No lateral deviation. L/R 9 pd.
Synoptophore :—S.P. angle—centre ... L/R 3 to 6 pd.
20° to right ... L/R 12 pd.
20° to left ... L/R 2 pd.
Fusion—0° L/R variable 0 to 6 pd.
Adduction to +15°.
Abduction to −4°.
Some improvement after operation, but still considerable diplopia to the right.

OPERATION. December 10, 1942.

Myectomy of the left inferior oblique.

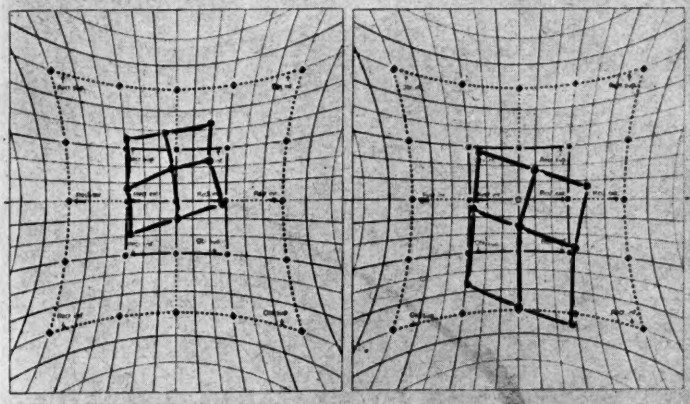
Case No. 34.

HESS CHART.

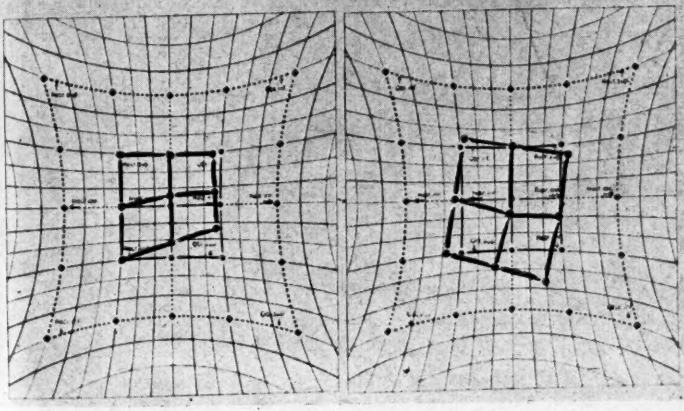
BEFORE FIRST OPERATION.

LEFT EYE.
PARESIS OF SUPERIOR OBLIQUE

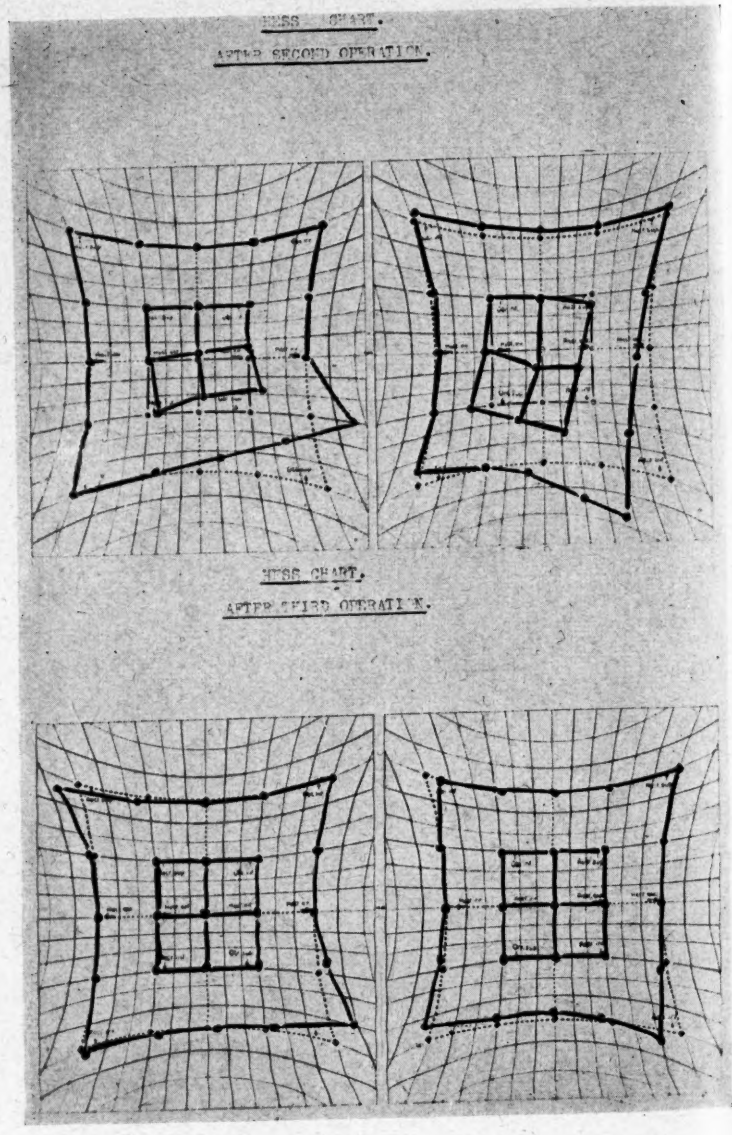
RIGHT EYE.
PARESIS OF THE SUPERIOR RECTUS. (SECONDARY.)



HESS CHART.
AFTER FIRST OPERATION.



CASE 34.


MESS CHART.
AFTER SECOND OPERATION.
MESS CHART.
AFTER THIRD OPERATION.

POST-OPERATIVE MEASUREMENTS.

Movements :—Still show over-action of right inferior rectus, and maximum diplopia still on dextro-depression.

Synoptophore :—S.P. angle—centre ... +3° L/R 1 to 2 pd. L. excyclophoria 5°.
20° to right L/R 7 to 8 pd.
20° to left L/R to 0 to 1 pd.
Fusion—0°. No hyperphoria. Excyclophoria 2°. Breaks on right on account of L. hyperphoria.
Adduction to +23°.

OPERATION. January 5, 1943.

Recession of right inferior rectus—2 mm.

POST-OPERATIVE MEASUREMENTS.

Movements :—Much improved but still slightly defective depression of left eye.

Maddox rod :—Esophoria 2 R/L ½ pd.

Diplopia :—Still slight diplopia down and to the right, does not worry him.

Synoptophore :—S.P. angle—centre ... +2°. R/L 2 pd.
20° to right ... L/R 3 pd.
20° to left ... R/L 1 pd.
Fusion—0°. No hyperphoria.
Adduction to +30°.
Abduction to −4°.

DISPOSAL.

Discharged January 12, 1943—very satisfactory.

Re-checked four months later—May 31, 1943. Said his eyes seemed quite satisfactory except for occasional diplopia in the evenings when his eyes tired. Reported that the upper image now belonged to the left eye, and felt that perhaps the previously weak muscle was recovering. On examination, this proved to be the case and the measurements were as follows :—

Maddox rod :—Fixing right—Esophoria 4△ R/L 3 pd.
Fixing left Esophoria 3△ R/L 1 pd.

Movements :—To the right—normal.
To the left—slight defective depression of the right eye.

Synoptophore :—S.P. angle—centre ... +1° R/L 2 pd. } Fixing
25° to left ... R. hyperphoria 4 pd. } right.
centre ... +1° R/L 3 pd. } Fixing
25° to left ... R. hyperphoria 5½ pd. } left.

DISPOSAL.

To duty. Checked three months later, measurements the same.

COMMENT. This case is described for three reasons . (1) There was a lesion of the central nervous system which affected initially the pyramidal tracts. (2) The necessity for the double recession of the contralateral synergist as well as the myectomy of the direct antagonist. (3) The seven months " follow up " period which showed that some additional recovery took place up to ten months from the date of the injury.

CASE No. 37.

HISTORY.

F. J. G., aged 24 years. Navigator. On April 25, 1944, was flung from an aeroplane, when the instructor turned the aircraft into a dive. Made a safe parachute landing from 4,000 feet, his only injuries being a small laceration of the right fronto-parietal region and a left frontal haematoma. He flew as a passenger the next day with no ill effects. Six weeks later when he was digging in the garden, he experienced a cold numb feeling in the right side of his face with a rapid onset of diplopia and loss of power and sensation in the legs. He was transferred to a military hospital for head injuries, where the diagnosis of a small intramedullary haemorrhage in the mid-pontine region was made.

When seen at hospital there was a paresis of the right superior oblique. At the examination, some five weeks after the onset of the diplopia, the ocular condition was as follows.

EXAMINATION. July 15, 1944.

Vision :—R. 6/6. L. 6/6.

Movements :—There was no obvious limitation of movement of the right eye, but a slight overaction of the left inferior rectus, on laevo-depression was demonstrable.

Diplopia :—Present on laevo-version and depression ; maximum displacement at the latter position, the more displaced image belonging to the right eye.

Maddox rod :—*Exophoria 4 pd. R/L 6 pd.*

Synoptophore :—S.P. angle—centre ... −1° R/L 1·5 pd.
20° to left ... R/L 3·5 pd.

Fusion −1° R/L 1·5 pd.
Adduction to +35°.
Abduction to −4°.

No infraduction.

Hess chart :—Right eye—paresis of right superior oblique.
Left eye—overaction of left inferior rectus.

Diagnosis :—Paresis of right superior oblique.

On August 28, 1944, on return from 14 days sick leave, the right hyperphoria had *decreased to 1 pd. Fusion was maintained to the left, and he felt that his eyes were* still improving.

DISPOSAL.

No operation advised. Return to unit for non-flying duties for two months.

COMMENT. It was considered by the neurological specialists that the intra-*medullary haemorrhage could be properly attributed to the head injury which this* navigator sustained on leaving the aircraft, although it was unusual for symptoms such as these to be delayed for so long.

Orthoptic treatment was given both at the military hospital and again at the R.A.F. hospital when the patient was transferred. From a right hypertropia of 12–16 pd., with constant diplopia the muscle imbalance had decreased to R/L 1 pd. *in three months.*

CASE No. 49.

HISTORY.

G. W. C., aged 24 years. Fitter, under training as Flight Engineer. Head injuries (i) in 1938 playing football, unconscious 3 to 4 days, (ii) in 1942 at football, unconscious 1 hour, (iii) *in 1943 playing ice hockey, unconscious 12 hours. After* last accident he was transferred to hospital for eye treatment.

PRE-OPERATIVE EXAMINATION. August 21, 1943.

Vision :—R. 6/5. L. 6/5.

Movements :—On looking to the left, the right eye turns up and the left eye turns down.

Diplopia :—Vertical straight ahead, increasing to the left ; maximum separation of images on laevo elevation, upper image belonging to the left eye.

Maddox rod :—Fixing right and left—Esophoria ½, *R/L 8 pd.*

Synoptophore :—S.P. angle—fixing right—centre ... 0°. R/L 13 pd.
to right ... 0°. R/L 4–6 pd.
to left ... 0°. R/L 22 pd.
fixing left —centre ... 0°. R/L 7–12 pd.
to right ... 0°. R/L 5 pd.
to left ... 0°. R/L 24 pd.

Measurements were variable and unsteady. Marked suppression *left eye. Suppressed left eye on fusion.*

Hess chart :—Suppressed too much, initially, for charting, but after 14 days orthoptic treatment shows :—

Right eye—paresis of right superior oblique ; overaction of inferior oblique.
Left eye—paresis of superior rectus ; overaction of inferior rectus.

Diagnosis :—*Paresis of left superior rectus with overaction of the right inferior* oblique and secondary palsy of the right superior oblique.

FIRST OPERATION. September 13, 1943.

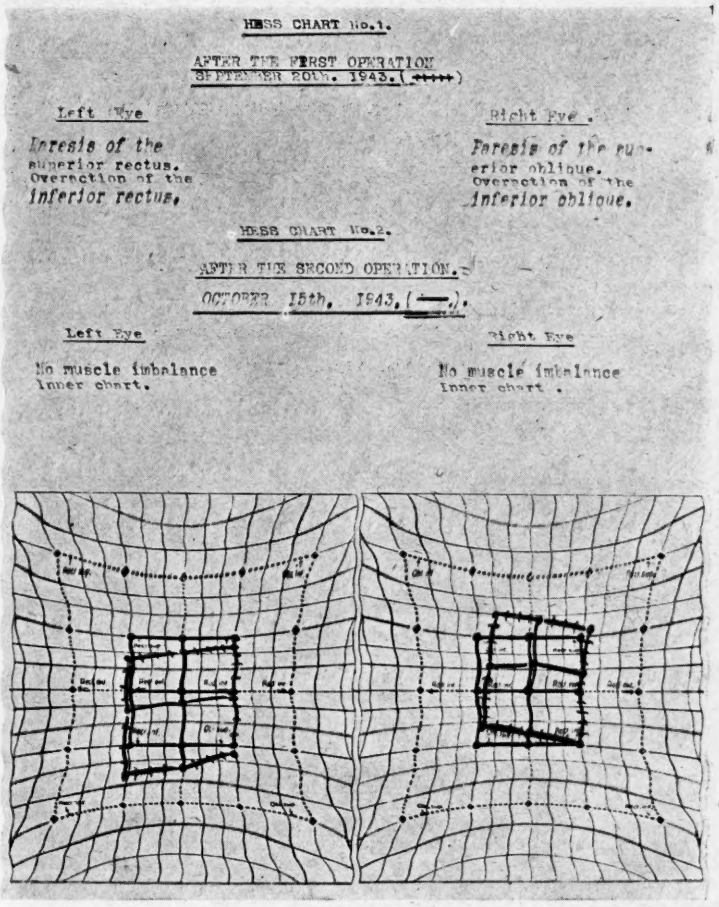
Myectomy of right inferior oblique.

POST-OPERATIVE MEASUREMENTS.

Synoptophore :—S.P. angle—fixing right—centre ... −2° R/L 4 pd.
to right ... −2° R/L 2 pd.
to left ... −2° R/L 16 pd.
fixing left —centre ... −2° R/L 4 pd.
to right ... −2° R/L 2 pd.
to left ... −2° R/L 17 pd.

Fusion momentarily with no hyperphoria ; no ductions.

CASE 49.



Diplopia :—*On looking upwards and to the left with excyclophoria*
Hess chart 2 (September 20, 1943).

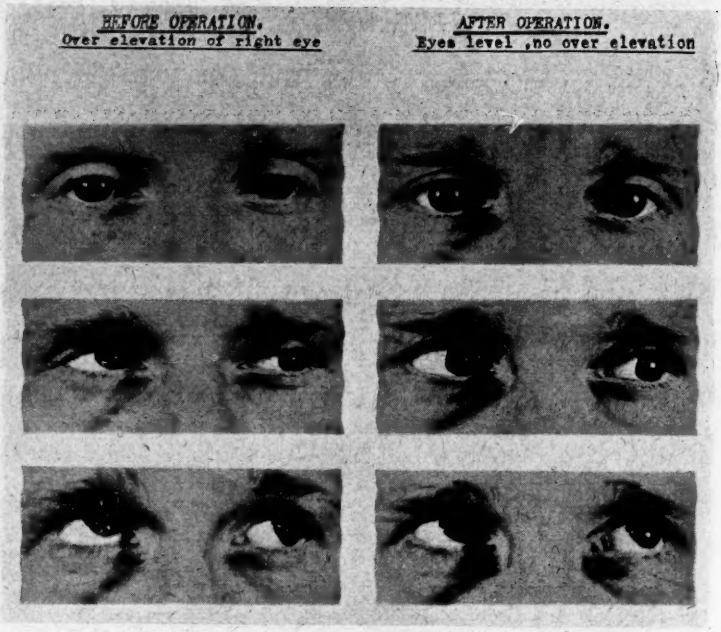
SECOND OPERATION. September 21, 1943.

Recession of left inferior rectus—3 mm.

POST-OPERATIVE MEASUREMENTS.

Maddox rod :—L/R 9 pd (over-correction).
Synoptophore :—S.P. angle—centre ... 0° L/R 6–7 pd.
to right ... 0° L/R 9 pd.
to left ... 0° L/R 1 pd.
Fusion—0° L/R 7 pd.
Supraduction to L/R 4 pd.

CASE 49



MEASUREMENTS AFTER THREE WEEKS SICK LEAVE.

Maddox rod :—Exophoria 1 pd. L/R 1–2 pd.

Synoptophore :—S.P. angle—centre ... L/R 1 pd.
to right ... L/R 1–2 pd.
to left ... L/R 2–3 pd.

Fusion—0°. No hyperphoria.
Adduction +15°.
Abduction −5°.

Hess chart 3 :—No muscle imbalance ; inner chart (October 15, 1943).

On October 23, 1943, discharged to duty.

Re-admitted to hospital on January 13, 1944. Diplopia has recently recurred. After 2 hours close work the image seems to tilt and separate. Diplopia most marked to the right, showing slight overaction of the left inferior oblique.

EXAMINATION.

Maddox rod :—Fixing right—Exophoria ½△, L/R 1 pd.
Fixing left—Exophoria ½△, L/R 1–2 pd.

Synoptophore :—S.P. angle—L/R 1 pd.—decreasing to 0 to the left.
increasing to 2△–3△ to the right.

Fusion—0°. L/R 2 pd. Excyclophoria 2°.

THIRD OPERATION. January 21, 1944.

Partial tenotomy of left inferior oblique.

POST-OPERATIVE MEASUREMENTS. January 25, 1944.

Maddox rod :—Exophoria 1–2 pd. L/R 1 pd.

Synoptophore :—S.P. angle—1°–2°. L/R 1–2 pd.

RE-EXAMINED—April 29, 1944.

Maddox rod :—Orthophoric, laterally—L/R ½–1 pd.
Synoptophore :—S.P. angle ... 0°. L/R 1½ pd.
Fusion ... 0°. L/R ½ pd.
Ocular movements full, no diplopia.
DISPOSAL. To Medical Board. Taken off flying on account of his head injuries, and not for ocular reasons.

CASE No. 52.

HISTORY.

A. P. C., aged 22 years. Pilot. Crashed on October 21, 1942, in a glider. His face was lacerated and left maxilla fractured. The fronto-malar suture was wired at hospital. He noticed double vision immediately after the accident. The diplopia *has improved and now has single vision below eye level. First seen three months* after the accident, when there was some ptosis of the left upper lid, enophthalmos and displacement of the left eye downwards. Admitted to hospital again five months after the accident for treatment of his diplopia.

PRE-OPERATIVE EXAMINATION.

Stereoscopic films showed that the position of the floor of the left orbit was satisfactory.
Vision :—R. 6/6. L. 6/6.
Movements :—Defective elevation of the left eye. Over elevation of the right eye.
Limitation of internal rotation of left eye.
Diplopia :—Vertical above eye level ; the higher image belonging to the left eye.
Little difference to right and left. Horizontal. Crossed diplopia to the right.
Maddox rod :—Fixing right—Exophoria 2°. R/L 10–16 pd.
Fixing left —Exophoria 3°. R/L 5 pd.
Synoptophore :—S.P. angle—fixing right and left—centre ... R/L 9–11 pd.
to right −5, R/L 15 pd.
to left ... R/L 7 pd.
to right—excyclophoria 10°.
to left excyclophoria 3°.
Fusion angle—0°, R/L 7 pd., excyclophoria 3 pd.
Adduction—poor, +10° (approximately).
Abduction to −2°.
Hess chart 1 :—Left eye—paresis of elevators.
Right eye—overaction of elevators.
Diagnosis :—Left third nerve paralysis with partial recovery and residual paresis of left superior rectus, left inferior oblique, and left internal rectus.

OPERATION.

Recession of right superior rectus. Tenotomy of right inferior oblique.

POST-OPERATIVE MEASUREMENTS.

Maddox rod :—Orthophoric.
Diplopia :—No diplopia at 30° above eye level. Some R/L on further elevation.
For this he compensates by slightly raising his head.
Synoptophore :—S.P. angle—centre ... 0° R/L 1·5 pd.
to right ... −5°, R/L 5 pd.
to left ... +4°, R/L ½ pd.
Fusion—0°. No hyperphoria holds to 25 to right or left.
Adduction to +25°.
Adduction to −3°.
Stereoscopic vision full.
Hess chart 2 :—No muscle imbalance on inner chart.
DISPOSAL. To Central Medical Board, where he was passed fit for limited (i.e. non-operational) flying.

CASE No. 53.

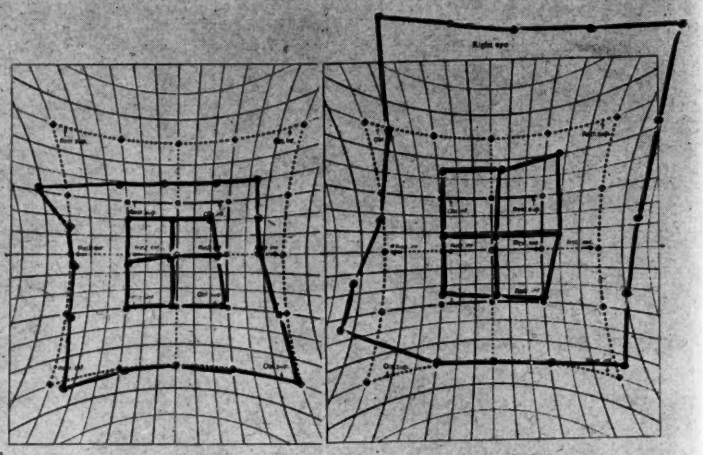
HISTORY.

F. M., aged 23 years. Pilot. Aircraft crashed over Germany in November, 1941. P.O.W. in Stalag Luft III for three years. He was badly concussed and saw double from the time of regaining consciousness. There has been no improvement in the diplopia ; he has adopted a marked head tilt downwards and to the right. Now repatriated ; admitted to hospital on account of the constant diplopia.

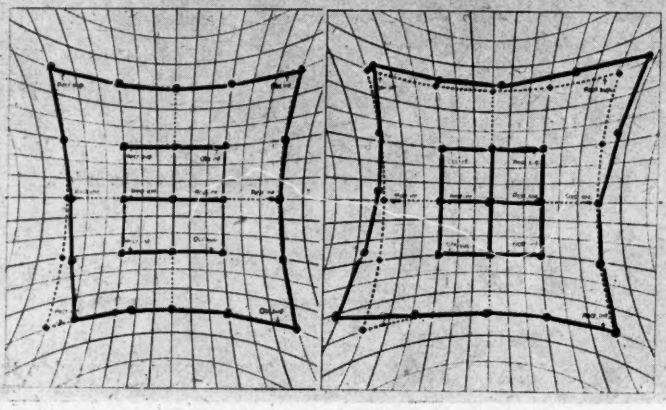
CASE 52

PRE OPERATIVE HESS CHART.

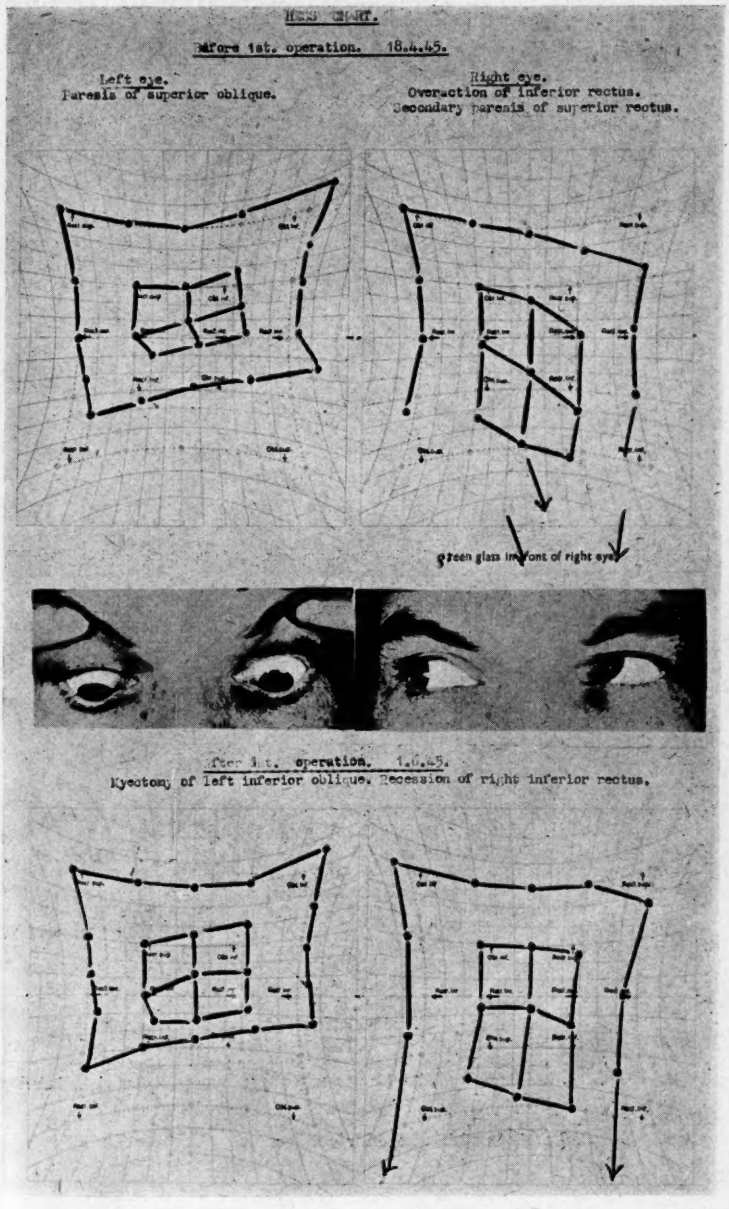
Paresis of left elevator muscles. Overaction of right elevator muscles.



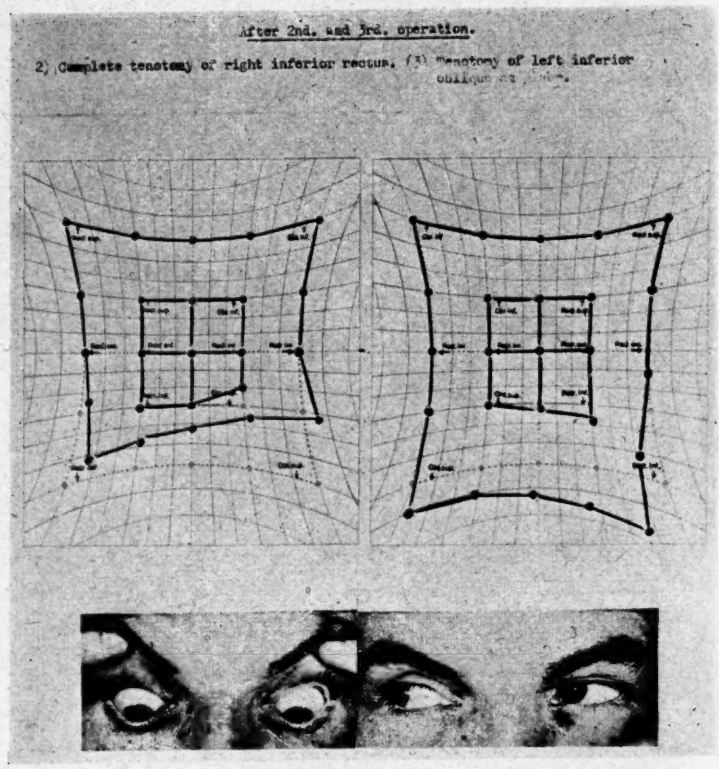
POST OPERATIVE HESS CHART.



CASE 53


Before 1st. operation. 18.4.45.
Left eye.
Paresis of superior oblique.
Right eye.
Overaction of inferior rectus.
Secondary paresis of superior rectus.
Green glass in front of right eye
After 1st. operation. 1.6.45.
Myectomy of left inferior oblique. Recession of right inferior rectus.

CASE 53



PRE-OPERATIVE EXAMINATION. April 17, 1945.

Vision :—R.E. 6/6 with + 1·0 sph = 6/4.
L.E. 6/12 with + 1·0 sph/+1·25 c 145° = 6/6.

Movements :—Defective depression of L.E. and overaction of R.E. to right, marked overaction of L.E. on elevation.

Diplopia :—Vertical. Maximum displacement of images on dextro-depression and laevo-elevation.

Maddox rod :—Controlled, Esophoria 7△ L/R 7△–8△. Relaxed, L/R 32△–35△.

Synotophore :— S.P. centre ... +4° L/R 8△. +4° L/R 26△ Excyclo 6
To right ... L/R 26△. L/R ++
To left ... L/R 4△ Excyclo. 4°. L/R 14△.
Fusion +3°, L/R 7△, Excyclo 5°
Adduction −10°. Abduction—1°.
Stereoscopic vision full but considerable suppression of left eye.

Hess chart :—L.E.—Paralysis of left superior oblique ; overaction of left inferior oblique. R.E.—Paresis of right superior rectus ; overaction of right inferior rectus.

Diagnosis :—1. Concussion.
2. Paralysis of left superior oblique.

OPERATION. May 2, 1945.

Myectomy of left inferior oblique. Recession of right inferior rectus.

POST-OPERATIVE MEASUREMENTS. May 14, 1945.

Maddox rod :—F.R. Esophoria 5△ L/R 3△.
F.L. Esophoria 7△ L/R 4△–5△.

Ocular Movement :—Good, up and to right, but marked overaction of R.E. on depression.

Synoptophore :—S.P.—centre ... +4°, L/R 2△ Excyclo 4°.
to right ... +4°, L/R varying to 14△.
to left ... +4°, L/R ½△ to 1△.
Fusion +4°, L/R 2△ breaking to R.
Adduction +8°. Abduction to +1°.

RE-ADMITTED—May 30, 1945.

Measurements substantially the same.

OPERATION—June 6, 1945.

Complete tenotomy and freeing of right inferior rectus.

POST-OPERATIVE MEASUREMENTS. June 6, 1945.

Unimproved.

CASE 54.

RIGHT 6th.NERVE PALSY.
Subject looking to the right, showing:-
1) Complete paralysis of right external rectus, with overaction of left internal rectus, prior to operation.
2) 15° binocular movement to right, following "O'Connor's" operation.

OPERATION. July 13, 1945.

Tenotomy of left inferior oblique at the globe.

POST-OPERATIVE MEASUREMENTS. July 17, 1945.

Synoptophore :—Angle—centre ... +2°.
20° to R. ... L/R 4△.
20° to L. ... L/R 3△.
Fusion 0. Adduction to +20°. Abduction to 2°.

ON RELEASE FROM THE SERVICE.

There was no diplopia ahead or to the left, some diplopia on looking down and to the right, for which he compensated by bending his head. Movements were good and head held much straighter.

Hess chart :—No. 3 shows the comparatively small asymmetry confined to the lower right quadrant. It is perhaps important to note that (1) this officer had been a P.O.W. for three years, during which time he had received no treatment for his diplopia.

(2) That the recession and subsequent tenotomy of the right inferior rectus, reduced but did not completely eliminate the overaction of this muscle.

(3) That a generous tenectomy of the left inferior oblique, at its origin, similarly only reduced its overaction.

(4) That a tenotomy of the inferior oblique near its insertion to the globe, reduced the vertical height by another 10 P.D. in the line of action of the muscle. to render the subject orthophoric ahead and to the left.

CASE No. 55.

HISTORY,

J. S. B., aged 24 years. Air gunner. First noticed serious trouble with vision in March, 1945. When using binocular reflector sights, during advanced training at an operational training unit, the target became double. He has also inclined his head to the left all his life, especially when reading.

Vision :—R. 6/6. L. 6/6.

Movements :—Defective elevation of right eye to left. Defective depression of left eye to left.

Diplopia :—Vertical upwards and downwards to the left.

Maddox rod :—Esophoria 5△. L/R 3△.

Synoptophore :—

	R.	C.	L.	
	FL+3° L/R 1△	+4° L/R 5△	+5° L/R 17△+	Varies.
	FR+5° L/R 3△	+5° L/R 6△	+8° L/R 13△+	

Fusion +4° 0, breaks L/R 5° to L. of midline.
Adduction to +10°. Abduction to+2°.

Hess chart :—Paresis of left inferior rectus. Gross overaction of right superior oblique.

Diagnosis :—Paresis of left inferior rectus.

OPERATION. June 30, 1945.

Recession left superior rectus 3 mm.

POST-OPERATIVE MEASUREMENTS. July 5, 1945.

Synoptophore :	R.	C.	L.
Angle	FL. zero	0° L/R 2△ incyclo. 5°	+3° L/R 22△ incyclo 5°.
	FR. L/R 1△	0° L/R 2△–3△ incyclo. 2°	+7° L/R 17△.

Fusion 0° θ ahead, holds to 15°–15°, then marked L/R.

Improved on laevo-elevation but diplopia on laevo version.

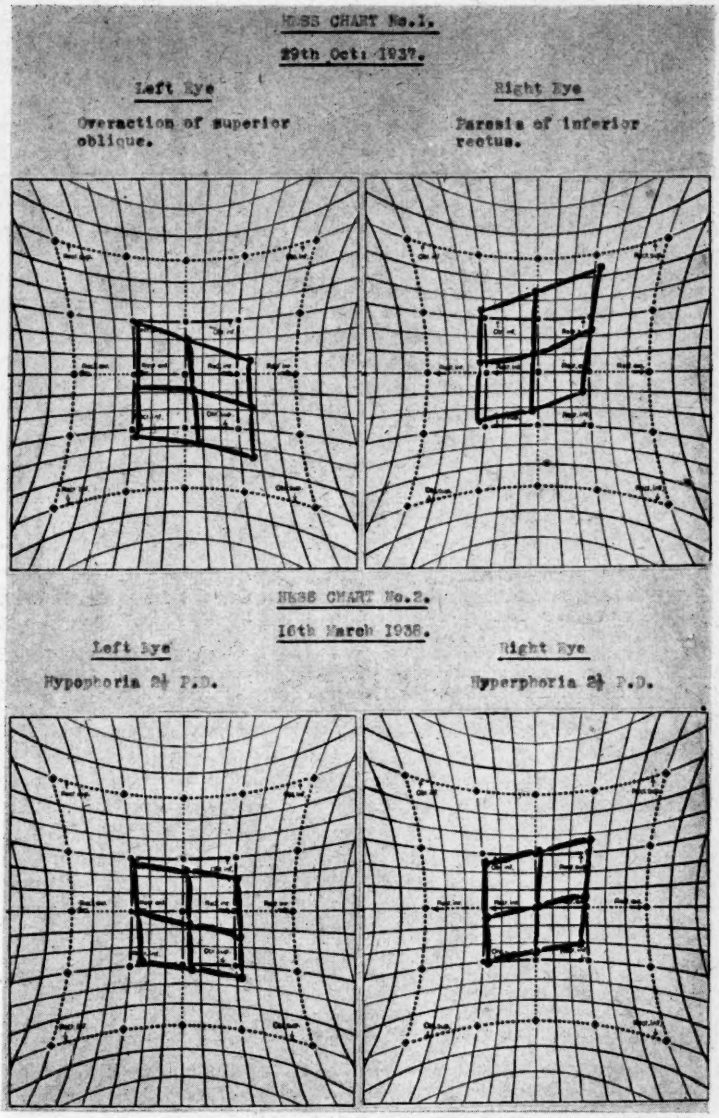
OPERATION. August 9, 1945.

Recession right superior oblique 3·5 mm.

POST-OPERATIVE MEASUREMENTS.

Ocular Movements :—Better to left, though still some L/R which is greater on elevation. To right there is defective depression of right eye and R/L : with incyclophoria increases on depression ? adhesions of right superior rectus limiting downward movement of the eye.

Synoptophore (August 17, 1945) :—R.—+8° R/L 8△–10△ incyclo. 2° C. : +4° R/L 2△. L. : +8 L/R 14△–15△ incyclo 5°.
Fusion 0° θ, centre breaking to right and left.


HESS CHART No.1.
29th Oct: 1937.
Left Eye
Overaction of superior oblique.
Right Eye
Paresis of inferior rectus.
HESS CHART No.2.
16th March 1938.
Left Eye
Hyperphoria 2½ P.D.
Right Eye
Hyperphoria 2½ P.D.

OPERATION. August 20, 1945.

Removal of catgut stitches from right superior oblique and recession of right superior rectus.

POST-OPERATIVE MEASUREMENTS. August 22, 1945.

Synoptophore :—*S.P.—R. : 0. C. : L/R 12△-14△. L. : L/R++.*

Movements :—Defective elevation of right eye, to keep eye padded.

Synoptophore (August 30, 1945) :—

S.P. angle +7° L/R 4△ centre.

Fusion +4° 0, breaks 10° to left.

M.R. F.R. Eso. 7△ L/R 2△.

F.L. Eso 4△ L/R 7△.

Fourteen days sick leave.

OPERATION. *September 24, 1945.*

Tenotomy of left superior rectus.

POST-OPERATIVE MEASUREMENTS. November 3, 1945.

Ocular Movements :—Defective R. dextro-depression, with downshoot of *L.E.*

Diplopia :—In all fields, except for limited field of S.B.V. straight ahead.

Hyperphoria and cyclophoria increasing to R.

Maddox rod :—F.L.= Eso. 8△ R/L 3△-4△. F.R.= Eso. 7△ R/L 1△.

Maddox wing :—Eso. 3° R/L 1°. Excyl. 3°.

Cover Test :—*S.L.C.R.R. and R/L 7△ F.R.*

Cyclophoria :—On dextro-version, R. Excyclophoria, with fairly good control.

Synoptophore :—S.M.P. angle—F.R. 20° R. = +5° R/L 5△. Excyl. 4°.

0 = *+5° R/L 3△. Excyl. 2°.*

20° L. = +5° 0.

F.L. 20 R. = +5 R/L 3. Excyl 8.

0 = +5 R/L 1. Excyl. 5.

20 L. = +5

Fusion +3° R/L 2△. Excyl. 3°.

Can hold S.V. "buckets" at + 3° R/L 2△. 5° R. and 8° L.

Hyperphoria increasing to the R.

Adduction *+20°. Abduction −1°.*

2△ Prism base 45° R. 2△ Prism base 225° L. Ordered for constant wear, *pending further operation.*

November 11, 1945. Adduction now +40° with increasing R. excyl.

The condition is still very unsteady. To proceed on leave for 2/12 and then *for re-admission. At present the most troublesome feature is the R. excyclophoria,* which worries him considerably. The hyperphoria is relieved to a certain extent by the clip-on prisms, at eye-level.

March 17, 1946. *Re-admitted to hospital. Eyes more settled. Measurements as* before.

Maddox rod :—Eso. 10△ R/L 5△ F/L. Eso. 10△ R/L 1△ F.R.

Maddox wing :—Eso. 5° R/L 2°. Excyclo *6°.*

Synoptophore :—S.M.P. F.R. 20° R. = +8° R/L 6½△. R. Excyclo 6°.

0 = +6° R/L 3½°. R. Excyclo 4°.

20° L. = 6° R/L 1△. No cyclo.

F.L. +7° R/L 6△. R. Excyl. 8°.

+6° R/L 3△ R. Excyl. 5°.

+6° 0. No cyclo.

Fusion +5° R/L 1△. R. Excyclo. 4°. R. Infraduction = 2△.

Fusion held 8° R. and L.

Adduction +42°. Abduction to 0°.

Myectomy Right Inferior Oblique (March 19, 1946) :—Greatly improved. Much larger binocular field.

Maddox rod :—Eso 8△ 0 F.R. Eso. 8△ R/L 1△ F.L.

Synoptophore :—*F.R.* 20° R. = +4° R/L 2△. No cyclo. F.L. +4° R/L 3△.

0° = +4° 0 No cyclo. +4° 0

20° L. = +4° L/R 8△. No cyclo. +4° L/R 10△.

Fusion +2° 0 held 15° R. and 10° L.

Adduction +45°. Abduction −3°.

ON DISCHARGE FROM HOSPITAL.

Ocular movements improved. Still marked L. hyper. on laevo-version and elevation. Can read, etc., without discomfort. Single binocular field of 40° to 3/330. *Very satisfied with result, and can avoid residual diplopia by turning the head.*

Prisms no longer necessary.

ANNOTATION

Through a Glass, Darkly

A note on contact lenses in a recent issue of the Journal has prompted a colleague who recently visited America to send a newspaper cutting which reads as follows:

"Anthony Aiello, convicted killer, was captured yesterday afternoon in Brooklyn in an anticlimatic last chapter in the round up of nine prisoners who broke out of the Raymond Street jail three months ago . . . he came back two weeks ago . . . got the rest of his cash and spent one hundred dollars for a pair of contact lenses to replace the identifying glasses."

This seems to bring right up to date the long list of favours which the science of optics has bestowed upon the malefactor, garnished with those bright, hard little touches of commercial efficiency which seem so characteristic of the American criminal. As yet the English criminal has not got as far as this; but then neither has the English contact lens industry; it is doubtful whether he could have arranged an appointment in this country in three months. We go about these matters more deliberately.

Nevertheless our criminals have not altogether despised the benefits which science has to offer. It was the operation of the laws of geometrical optics which darkened the lantern in the sturdy grasp of the unwitting Bill Sykes, in that tidier, simpler pre-Einstein era when the rays of light, like the British Army of the day, could be relied upon to manoeuvre in thin straight lines.

Perhaps this American note is the writing on the wall; perhaps spectacle-making and spectacle-wearing have passed the peak and must fall into decay and disuse. It is not easy to visualise, however, an ophthalmic world bereft of those twin diseases of vitreophobia and vitreophilia—the dread of glasses and the morbid craving for them—which are commonplaces of the consulting room. Will contact lenses solve the problem of the boy who throws away his spectacles the day after he leaves school or the young female presbyope who considers the occasional use of reading lenses a fate worse than death? We doubt it. But even these disorders pale before the iron determination of the glasses addict. From the voluminous handbag, or in the most intractable cases, from the capacious reticule, come pair after pair of spectacles, with lenses of every conceivable shape and hue, agreeing only in dioptric power; they have been prescribed by opticians, by ophthalmic surgeons, by half the great names of Harley Street, but all have been found wanting. Undeterred by the chastening power of experience, nothing will satisfy the craving but bigger and better lenses, of

greater 'magnifying power', combined of course with a corresponding reduction in the transmission of the well known baleful properties of light.

Not even contact lenses can solve this problem; 'not the labours of my hands, can fulfil thy law's demands'. There is perhaps hope for the refractionists yet, if only for the psychological comfort of their ministrations. It is difficult to see how contact lenses can meet the needs, the urgent imperative needs, of the young women (or the not so young women) who find the daylight too strong for them. Who is not familiar with the cold azure gaze of these maidens, entrenched behind the deepening tints of Crookes glass? With them the spectacle maker may take heart again; No contact lenses will fill their needs, for they are symbolic; no matter how carefully the conscious mind is dressing the shop window, with them the subconscious is already putting up the shutters.

FACULTY OF OPHTHALMOLOGISTS

In an effort to meet the objections of some Members and Associates that the activities of the Faculty were insufficiently advertised, and were only susceptible to comment once a year on the occasion of the Annual General Meeting, the Council at their last meeting on July 11, decided that an account of the more important actions and decisions of the Council at meetings should be prepared by the Honorary Secretary and submitted for publication to the Medical Press. An account of the last meeting, held on July 11 from 2.15 p.m. till 5 p.m. is appended.

Owing to the removal of Mr. P. M. Wood from Scotland to Halifax a vacancy had occurred among the Full-time Associate Representatives on the Council. It was decided to fill this casual vacancy by asking the Full-time Associates in Region 6 to vote for a representative. Only three voting papers had been returned and only one of them bore a vote. It was therefore decided to leave this Region unrepresented.

The President reported that, as "the appointed day" for the beginning of the National Health Service had been postponed, he had agreed with the British Medical Association's suggestion that the appointment of the medical members on the Professional Committees to prepare lists of participants in the Supplementary Eye Service should be deferred until the reaction of the general body of ophthalmologists to the Interim Report of the Eye Services Committee had been obtained. This was agreed.

A Hospital Services Committee has been set up with the following terms of reference:—

"To consider facilities for ophthalmological services, including education and research, under the National Health Service."

Representatives from the Universities, Teaching and other Hospitals have been invited to form regional Sub-Committees in Scotland, the Provinces and London, and to submit plans for the consideration of the main Committee.

In connection with the question concerning the fee of four guineas per session for Local Authority Work, it was stated that the matter had been raised at the last B.M.A. Council and that it was not possible to alter the four guinea rate, as this had been agreed for all consultant and specialist work. but that the question of £2 17s. 6d. for refraction work being increased was still under consideration.

It was reported that the question of study visits to clinics abroad was in hand, and that it was likely that some would be arranged for next year.

It was learned in connection with the Joint Committee of the Faculty and the British Optical Association, which had been appointed to consider the training of contact lens fitters, that the Association of Dispensing Opticians had been invited to nominate a representative to serve on the Contact Lens Board, which is now in process of formation.

The suggestion that the Faculty should organise a discussion on the Education of Blind and Partially Sighted Children was referred to the Ophthalmological Section of the Royal Society of Medicine.

The Honorary Treasurer reported that he had collected £64 in private donations from members of the Council to assist an orthoptist who had suffered bilateral detachment of the retina, and had passed the money over.

The rest of the meeting was occupied by routine and domestic matters.

FRANK W. LAW,
Hon. Sec.

CORRESPONDENCE

COLOUR VISION IN THE CONSULTING ROOM

To the Editors of THE BRITISH JOURNAL OF OPHTHALMOLOGY.

DEAR SIR,—Dr. Neubert's explanations in his letter in your August number are not convincing. In my letter I suggested that

the difference between the usually accepted 7-8 per cent. incidence of defective colour vision and the figure of 5·5 per cent. found by Dr. Neubert in his series, might be due to the methods of testing. It is no answer to this criticism to say that the difference must be due to the non-random method of sampling—it may be, but it might equally be the method of testing.

It is never a waste of space to describe accurately the methods of testing employed—in fact it is fundamental. No two people use the Ishihara plates in exactly the same way. Further, it is not sufficient to describe a multi-light lantern as having a rheostat, apertures of a certain size and filters approximating to those recommended by the International Committee for Aerial Investigation. In view of repeated rheostat adjustments it was pure chance if any two of the subjects examined on the multi-light lantern were tested under the same conditions, and in this type of work the colour temperature of the source cannot be ignored completely.

Surely the choice of title of an article does not remove the necessity for laboratory control of the tests employed. Without such control there is no justification for saying that the results presented show a different function for single as compared with multi-light lanterns. It is equally permissable to come to the same conclusion, without any experimental work whatever, when seated in an arm-chair by the fire.

I apologise for a second letter but I feel very strongly that the idea should not be spread abroad that the testing of colour vision and the classification of colour defects can be carried out cavalier-fashion with black-out shades and coffee-tins—unless lanterns made from such materials are properly standardised and used under clearly defined conditions. The efficient testing of colour vision is no easy task.

Yours sincerely,

JOHN GRIEVE.

MEDICAL SCHOOL, DUNDEE.
August 20, 1947.

NOTES

University of Glasgow Department of Ophthalmology Autumn, 1947

DURING September and October a series of meetings will be held in the Department on Wednesdays at 8 p.m. The general arrangements will be similar to the series held last year. Tea will be served after the paper and a discussion will follow.

The meetings will be open to all medical practitioners and senior students interested in Ophthalmology.

September 24, Mr. F. Ridley, "Contact Lenses"; October 1, Dr. J. D. Fraser, "Industrial Cataract"; October 8, Prof. A. Loewenstein, "Pathology and Clinical Aspects of Ocular Glass-membranes"; October 15, Prof. A. J. Ballantyne, "Some problems in Ophthalmoscopic Diagnosis"; October 22, "Prof. W. J. B. Riddell, "Ophthalmology in Poland."

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National Society for the Prevention of Blindness

THE National Society for the Prevention of Blindness announces that it will hold a three-day conference, April, 5, 6 and 7, 1948, at the Hotel Radisson, Minneapolis, Minn. This conference will be of interest to persons who are directly or indirectly concerned with eye health and safety. Details concerning the programme may be obtained by writing directly to the Society at 1790, Broadway, New York 19, N.Y.

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The Estelle Doheny Eye Foundation. Eye Laboratory at Los Angeles

THE Estelle Doheny Eye Foundation announces the establishment of an Eye Laboratory located at St. Vincent's Hospital in Los Angeles, designed to provide certain modern ophthalmic facilities badly needed in Southern California.

The immediate functions of the laboratory are:—

1. To serve as a pathological laboratory for the diagnosis and registration of pathological specimens, with preparation of gross specimens and microscopic slides for ophthalmologists submitting specimens, and for the building up of a museum of eye pathology.

2. To serve as a bacteriological laboratory wherein diagnostic scrapings, smears and cultures can be studied, animal inoculations made, and the sensitivity of organisms to various drugs and antibiotics determined.

3. To provide facilities for fundus, gross, and slit-lamp photography, and to maintain a library of photographs and motion pictures for teaching of ophthalmology.

4. To provide an "Eye Bank" for Southern California, with registry of potential donors and recipients. Donor material will be collected, examined and distributed, and facilities may later be provided for limited instruction in corneal transplant procedures.

5. To distribute and loan certain drugs and equipment that are not otherwise available in the community.

6. To make available certain equipment for radiation therapy of the eye for use outside the laboratory.

Dr. Alan Woods, Professor of Ophthalmology at Johns Hopkins Medical School, Dr. Cecil O'Brien, Professor of Ophthalmology at

University of Iowa Medical School, and Dr. Phillips Thygeson, formerly Professor of Ophthalmology at Columbia University, and now Associate Professor at the University of California, will serve on the Advisory Board.. Dr. A. Ray Irvine, Professor of Ophthalmology at the University of Southern California, will act as Chairman of the original board. It is contemplated that the Advisory Board will also include prominent business and professional leaders as well as representatives from the eye departments of local hospitals, medical schools, and from the Eye Section of the Los Angeles County Medical Association.

Dr. Peter Soudakoff, formerly Associate Professor of Ophthalmology at the Peking Union Medical College, will serve as full time pathologist at the laboratory. As part of the residency programme of the Eye Service of the Los Angeles County General Hospital and of certain local Veteran's Hospitals, each resident will spend two or three months at the laboratory. It is anticipated also that a research associate, granted a fellowship in basic ophthalmic research by the foundation, will be added to the laboratory staff from time to time.

In creating this perpetual charitable foundation dedicated to the conservation and restoration of eyesight, Mrs. Edward Doheny, with great generosity and discerning wisdom, has been careful to insure a flexibility of organization to take care of the immediate practical needs and at the same time provide for eventual development of much needed research in ophthalmology.

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Let there be Light The 32nd annual report of the National Society for the Prevention of Blindness, 1946 has the above title. The year has shown a resurgence of activities and the report indicates that the society is in a flourishing condition. During the year a three-day conference was held which was largely attended, the whole being most successful. During the year the Society has established nine scholarships of $1000 for the education of qualified students interested in preparing for positions in the field of sight conservation and prevention of blindness. An industrial eye conservation programme has been worked out; and during a fortnight in June, the Society gave an intensive course of lectures and demonstrations at headquarters. Research is being actively undertaken, and nation-wide meetings are being organised. The campaign against glaucoma goes on. A summary of the year's finances completes the report.

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Corrigenda In the review of Kestenbaum's "Clinical Method of Neuro-Ophthalmologic Examination" p. 508, the publishers name should read Grune & Stratton, Inc. not Green & Stratton. And by an error the date 1949 was given for Troncoso's Treatise in gonioscopy in place of 1947.